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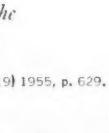

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COMPLICATIONS OF AORTOGRAPHY

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AN IMPORTANT DIAGNOSTIC and investigative medium became available in 1929 with the introduction of translumbar aortography by dos Santos and associates (12). Leriche and others, employing this method of study, observed the various patterns of thrombo-obliterative lesions in the terminal aorta and iliac arteries and were able to demonstrate conclusively the segmental nature of the disease. On the basis of these pathologic concepts, effective operative procedures were devised to restore more normal circulation, and in many clinics patients are now routinely selected for vascular operations on the basis of aortographic findings. The urologist has employed this method for some time in the study of renal disease because of its independence of renal function and its inclusion of the entire renal parenchyma and renal artery within the realm of observation. Characteristic abnormal renal vascular patterns are well known, and as a result of this procedure, it is now possible to detect lesions that were previously elusive.

Aortography is, therefore, well established as a valuable clinical diagnostic procedure, and the frequency and extent of its application is limited only by the risks involved. Its relative safety would appear to be substantiated by the numerous reported applications without incident and the general extent to which it is now being applied. Regardless of this apparent safety, review of the literature and individual experiences indicate that serious complications occur, and in view of the present lively interest in the study and treatment of aortic disease, the incidence of these complications is likely to increase. Accordingly, it would appear essential at this time to consider this problem. The purpose of this report is to review the recorded complications and to present certain observations derived from an analysis of our experience with 300 aortograms with particular reference to certain correctible factors that may be responsible for development of these disturbances.

The complications of aortography are pain, hemorrhage, thrombosis, embolism, renal insufficiency, neurologic disorders, allergic reactions, and other systemic disturbances that may be related more to the general anesthetic in those cases in which it is employed than they are to aortography. Each of these aforementioned complications will be considered separately.

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TABLE I.—SUMMARY OF CASES OF COMPLICATIONS OF AORTOGRAPHY COLLECTED FROM THE LITERATURE

Author	*Complication*	*Contrast medium*	*Total volume, c.c.*	*Injections*		*Associated factors*	*Result*
				No.	*Site*		
Deterling (11)	Chylothorax				Level of diaphragm	2 tears in thoracic duct	Controlled by thoracotomy
Joyeux, *et. al.*	Partial gangrene of large intestine	Tenebryl	16	1		3 gangrenous segments passed	Recovery
Lilly	Embolism—arteriosclerotic plaque					Attempted embolectomy	Loss of extremity
Ferguson	Embolism—thrombus from puncture site					Successful embolectomy	Recovery
McAfee and Willson	Hemorrhage at puncture	70% urokon	35	3		Position changed during procedure	Death
McAfee and Willson	Hemorrhage at puncture	70% urokon		4	Thoracoabdominal aneurysm	Hemorrhage	Death
Stephenson	Hemorrhage at puncture						Death
Wagner and Price	Superior mesenteric artery thrombosis	80% sodium iodide	10	1	Superior mesenteric artery		Death
Doss	Superior mesenteric artery thrombosis	80% sodium iodide		1	Superior mesenteric artery		Death
Sante	Superior mesenteric artery thrombosis	80% sodium iodide		1	Superior mesenteric artery		Death
Vitt	Superior mesenteric artery thrombosis	80% sodium iodide		1	Superior mesenteric artery		Death
Ferguson	Inferior mesenteric artery thrombosis	70% urokon		1	Inf. mesenteric artery		No adverse effects

PAIN

Little reference is made in the literature to pain as a single complication of aortography. Most of our patients complained of some discomfort deep in the back or high in the abdomen. Pain is usually mild and transient, but occasionally analgesics are required for complete control during the first 12 to 18 hours. At operation such patients are found to have a small area of ecchymosis in the retroperitoneal region of the aortic puncture. The exact incidence of extravasation of blood in our patients is not known, but extravasated blood has been found in almost all patients in whom a search for it was made at subsequent operation. The intensity and incidence of pain and the degree of extravasation of the contrast medium increase with the number of aortic punctures required. Trauma and hematomas occurring in the deep muscles of the back and retroperitoneal area from passage of a No. 17 needle have in all probability been partially responsible for the production of pain.

The incidence of ecchymosis in our series is somewhat higher than that registered in the few available reports. This discrepancy appears to be due to the difference in methods of observation. Thus, Larsson and Palmlöv reported 2 hematomas in 4 patients at autopsy 18 hours to 4 months after aortography. Smith, Rush, and Evans reported hematomas in 17 per cent of 36 patients at autopsy up to 24 days following the procedure. Small ecchymotic areas can be absorbed or reorganized in less time than allowed in these long periods of observation and this probably explains the low incidence in the experiences of these authors.

HEMORRHAGE

The few available reports of significant hemorrhage following aortography would suggest that this is a rare complication (Table I). McAfee and Willson reported 5 cases of periaortic hematoma in 150 aortograms. Three of these were of no clinical significance, but in the other 2 the complication

TABLE II.—SUMMARY OF CASES OF UNILATERAL RENAL DAMAGE COLLECTED FROM LITERATURE

Author	*Contrast medium*	*Total volume c.c.*	*No. of injections*	*Associated factors*	*Result*
Evans					Nonfunction kidney
Evans					Nonfunction kidney
Harvard	75% neo-iopax	12	1		Recovery
Larsson and Palmlöv					Reduced function
McAfee and Willson	70% urokon	15	1		Renal atrophy
Melick and Vitt					Recovery
Miller *et al.*	70% diodrast	50		Mechanical injection	Renal damage, 4 mos.
Miller *et al.*	70% diodrast	70	2	2 needle technique	Recovery, 13 weeks
Miller *et al.*	70% urokon	100	2	2 needle technique	Recovery
Ramey and Polley	70% urokon	33	2	Extravasation	Nephrectomy
Williams *et al.*	70% diodrast	50	1		Renal atrophy
Williams *et al.*	70% diodrast	50	1		Recovery

Right renal artery site of injection in all cases

eventually led to death. One of these patients had a thoracoabdominal aneurysm which required 4 separate punctures in order to outline the lesion completely. Severe abdominal pain and hypotension developed soon after performance of aortography and in spite of emergency resection of the aneurysm and administration of blood transfusions, the patient died of hemorrhage. Aortography was performed in the other patient in an effort to exclude renal disease as a cause of hypertension. During the study the patient had 2 injections (25 c.c. each) of 70 per cent urokon®, and on 2 occasions the patient's position was changed from prone to sitting with the needle in place. Profound hypotension immediately developed after the second change in position and required 4,500 cubic centimeters of whole blood during the next 48 hours. The daily urinary output rapidly diminished to 150 cubic centimeters and the patient died of acute renal insufficiency 15 days after aortography. Diffuse renal damage and a large left perinephric hematoma were found at autopsy. A patient who died of hemorrhage from the site of aortic puncture was observed by Stephenson, but details of the case are not available.

In our own experience bleeding from the site of puncture has not been a significant complication except in 1 patient in whom the primary contributing factor was a defect in the blood coagulation mechanism. An aortogram and resection of 2 aneurysms were successfully performed in this patient in spite of the prolonged blood coagulation time and its attendant complications. This case, however, illustrates the danger of aortography as well as operation in such patients and the effectiveness of whole blood and plasma in controlling the clotting defect. In view of these considerations and other interesting aspects of the disease, this case is presented in detail.

CASE REPORT

P. T., a man 54 years old, was admitted to the Methodist Hospital, Houston, Texas, May 15, 1956, for the study and treatment of a pulsatile mass in the right groin. Hypertension was discovered in 1948, and in December 1953 pain in the abdomen and chest extending into both groins suddenly developed. Almost immediately coldness and numbness appeared in the right leg. A diagnosis of arterial occlusion was made, and operation elsewhere revealed obstruction of the right iliac and femoral arteries by what appeared to be a thrombus. Partial removal of this resulted in some improvement of symptoms in the leg, but the patient continued to have a cool numb foot and intermittent claudication. Soon after operation a small pulsatile mass was observed in the wound, and during the succeeding 2½ years this mass gradually increased until it measured approximately 8 centimeters in diameter.

On admission the blood pressure was 210 millimeters of mercury systolic and 115 millimeters of mercury diastolic. The heart was slightly enlarged and a feebly pulsatile rounded mass measuring 6 by 8 centimeters was noted in the right groin. Pulses could not be palpated distal to the mass. The abdominal aortic pulsation was palpable over an abnormally large area and a large mass suggestive of an aneurysm was thought to be present. The clinical picture suggested the presence of a chronic dissecting aneurysm of the aorta and of the right iliofemoral artery which developed in 1953. The inguinal mass was obviously a false aneurysm which developed as a result of the previous operation. An angiocardiogram was inconclusive in establishing the diagnosis of dissecting aneurysm; con-

TABLE III.—SUMMARY OF CASES OF BILATERAL RENAL DAMAGE COLLECTED FROM LITERATURE

Author	*Contrast medium*	*Total volume c.c.*	*No. of injections*	*Status of aorta*	*Associated factors*	*Result*
Barnes *et al.*	70% diodrast	70	2	Aorta occluded	Aortogram 4 mos. previously	Recovery
Berg	70% urokon	40	1		Hypotension	Recovery
Ferguson	70% urokon			Abdominal aneurysm	None	Death
Fry	70% urokon	100	2	Normal	Previous I. V. P.	Death
Josselson and Kaplan	75% neo-iopax	15	1	Normal	Nonfunction left kidney	Death
Leguewe *et al.*	⅔ 85% abrodil	20	1			Recovery
Leguewe *et al.*	⅓ 100% sodium iodide ⅔ 85% abrodil	20	1			Recovery
Leguewe *et al.*	⅓ 100% sodium iodide ⅔ 85% abrodil	20	1			Recovery
Leriche *et al.*	⅓ 100% sodium iodide 70% urokon					Recovery
Miller *et al.*	70% diodrast	100	2	Occluded	Hypotension, transfusion, 2 needle technique	Recovery
Miller *et al.*	70% diodrast	60	2	Normal	Iodism	Recovery
Miller *et al.*	70% diodrast	70	2	Narrowing of aorta	2 needle technique	Recovery
Miller *et al.*	70% diodrast	50	1		Mechanical injection	Recovery
McAfee and Willson	70% urokon	50	2	Normal	Hemorrhage, transfusion	Death
Root	70% urokon	60	3	Occluded	2 needle technique	Recovery
Talley	70% urokon			Occluded		Death
Tarazi, et al.	70% urokon	50	2	Occluded		Death
Tarazi, et al.	70% urokon	50	2	Not occluded		Recovery
Williams, et al.	70% diodrast	50				Recovery

sequently, a translumbar aortogram was considered indicated to substantiate the clinical impression that an abdominal aortic aneurysm was present as well as to determine its possible relationship to a dissecting aneurysm. Two aortic punctures were required before a vigorous pulsatile blood flow was obtained and prior to injection of 25 cubic centimeters of 70 per cent urokon sodium.

The patient had mild pain in the abdomen and left flank upon recovery from the general anesthetic, and about 6 hours later hypotension developed associated with a tender rounded mass in the left side of the abdomen and left flank. The blood clotting time (Lee and White) was 21 minutes and 11 seconds, although other tests for bleeding tendencies were normal at that time. The blood pressure stabilized at its usual level after transfusion of 1,500 cubic centimeters of whole blood and 500 cubic centimeters of plasma, and the clotting time returned to normal levels. At operation 8 hours later, the mass proved to be a retroperitoneal hematoma, and even though the site of puncture was not exposed, there was little question that it was the source of hemorrhage. The external appearance of the aorta both above and for several centimeters below the renal arteries seemed normal. A moderate sized abdominal aneurysm was located below this point and on excision was found to be formed by a weakened area in the wall of the false lumen of a dissecting aneurysm. This aneurysm and the false aneurysm of the right femoral artery were excised and replaced by homografts. A period of mild hypotension occurred 3 days after operation when the clotting time again became elevated, but plasma therapy again reduced the clotting time and the patient recovered uneventfully.

The hemorrhage that followed aortography in this case was undoubtedly related to the prolonged clotting time of the blood since bleeding occurred after both aortography and operation when the clotting time was approximately twice normal, and on both occasions it was controlled by reducing the clotting time toward normal levels. Two aortic punctures in this case as in those previously reported with hemorrhage probably increased the likelihood of this complication.

RENAL COMPLICATIONS

Renal damage is the commonest significant complication of aortography and, therefore, constitutes the major risk of the procedure. There have been 31 recorded cases of renal injury with a mortality rate of 20 per cent. In 12 of these injury was unilateral, and in the remainder it was bilateral. All patients with unilateral damage survived; however, 6 patients, or 32 per cent, with bilateral injury died from renal insufficiency. As can be

TABLE IV.—PERTINENT DATA IN 9 CASES OF RENAL INJURY FOLLOWING AORTOGRAPHY

Patient	Renal injury	Contrast medium	Injections: Amount, c.c.	Injections: No.	Injections: Site	No. of aortic punctures	Degree of aortic destruction	Result
1. A. J. W.	Bilat.	70% urokon	100	2	Above renal A.	1	Complete occlusion, L_2	Recovery
2. F. W. R.	Bilat.	70% urokon	50	1	Above renal A.	1	Complete occlusion, L_3	Died
3. H. H.	Bilat.	70% urokon	35	1	Above renal A.	1	Complete occlusion, L_2	Recovery
4. J. C. S.	Bilat.	70% urokon	50	1	Above renal A.	1	Narrowing of aorta	Recovery
5. E. P. W.	Bilat.	70% urokon	40	1	Above renal A.	1	Normal	Recovery
6. A. J. W.	Bilat.	70% urokon	100	2	Above renal A.	1	Complete occlusion, L_3	Recovery
7. W. B.	Bilat.	70% urokon	50	2	Above renal A.	1	Normal L. iliac obstruction	Died
8. J. S.	Bilat.	80% sodium iodide	15	1	Above renal A.	1	Normal	Died
9. R. D. B.	Right	70% urokon	15	1	Orifice Rt. renal A.	2	Normal iliacs narrowed	Patient—recovered. Kidney—unknown

seen in Table II, the patients with unilateral damage had injection of the contrast medium directly into the renal artery, and those with bilateral injury received either small doses of sodium iodide or large amounts of other iodide compounds (Table III). It is also significant that many of these patients received multiple injections of the contrast medium and in some instances through 2 needles. The degree of aortic occlusion and the influence that this may have upon the amount of material shunted into the kidney and subsequent renal injury cannot be ascertained from the reported cases since this information was not given. It is more significant, however, to note the occurrence of injury in the absence of aortic obstruction.

In our series there were 9 cases of renal injury. One of these patients had unilateral damage from direct injection into the renal artery. Three of the 8 patients with bilateral injury succumbed from renal insufficiency. All 8 patients with bilateral damage were studied early in our experience when safe dosage of contrast medium was not fully appreciated. As seen in Table IV, our patients with renal damage also received either sodium iodide or relatively large doses of urokon sodium in single or repeated injections. The aorta was partially occluded in 1 patient, completely obstructed in 4 patients, and essentially normal in the other 4. The point of injection into the aorta was reasonably well above the origin of the renal arteries in all except the patient who had direct injection into the right renal artery. The contrast medium was manually injected through a No. 17 thin needle in all instances.

The clinical findings in 3 of these 8 cases with renal damage will be briefly described to illustrate the 3 categories of patients under study: survivals, nonsurvivals, and unilateral injury.

CASE 1. F. W. R., a white man 54 years old who had had intermittent claudication in both lower extremities for 2 years, was admitted to the hospital 7 hours after onset of pain and numbness of the left foot. Femoral pulsations were extremely weak, and pulses below this level were absent. The left foot and ankle were cold with blanching on elevation and had slow venous filling on dependency. The blood pressure was 180 millimeters of mercury systolic and 100 millimeters of mercury diastolic. On admission, urinalysis, blood count, blood urea nitrogen, prothrombin activity, serology, electrocardiography, and roentgenography of the chest yielded normal results.

The circulation in the left foot and ankle improved following symptomatic therapy and 1 week after admission translumbar aortography was performed following anesthetization with pentothal sodium®. A No. 17 thin needle was inserted into the abdominal aorta above the origin of the renal arteries and 45 cubic centimeters of 70 per cent urokon sodium was manually introduced. Because the roentgenogram was technically unsatisfactory, a second injection of 45 cubic centimeters of 70 per cent urokon sodium was carried out. The aortogram demonstrated complete aortic occlusion at the inferior aspect of the third lumbar vertebra with some irregularity of the wall above this level (Fig. 1).

FIG. 1. Aortogram in Case 1 demonstrating complete occlusion of the aorta at the inferior aspect of the third lumbar vertebra where there is relatively good egress of contrast medium through large lumbar arteries and the inferior mesenteric artery. Note the brilliantly outlined kidneys indicating a high concentration of iodine.

Soon after aortography there was a transient rise in blood pressure to 215 millimeters of mercury systolic and 115 millimeters of mercury diastolic associated with nausea and vomiting. The daily urinary output was less than 500 cubic centimeters during the first week following aortography after which it gradually rose to 1,200 cubic centimeters. Throughout this period the urine contained at least 20 milligrams per 100 cubic centimeters of protein, 10 to 15 erythrocytes and 8 to 10 leucocytes per high power field. The blood urea nitrogen was 67 milligrams per cent 24 hours after aortography and rose to 200 milligrams per cent on the thirteenth day when the patient died of uremia.

Autopsy revealed a small area of extravasated blood at the site of aortic puncture just above the origin of the superior mesenteric artery. The aorta was completely occluded by a well organized thrombus which extended from 2 centimeters below the renal arteries down to segments in each common iliac artery that had been narrowed by arteriosclerotic changes. Typical gross and microscopic findings were noted in the kidneys (Figs. 2, 3, and 4). Both the glomeruli and the tubules had been injured. Many glomeruli were completely disorganized and the tubular epithelium showed varying degrees of destruction.

CASE 2. E. P. W., a white man 44 years old, was seen in December 1954 because of pain in the abdomen and back. Numerous studies failed to reveal the source of the pain. The abdominal aortic pulsations were prominent and an aneurysm was considered probable, but because of the patient's size, this could not be established on clinical grounds. After anesthetization with pentothal sodium, a No. 17 thin needle was inserted into the aorta well above the renal arteries and 40 cubic centimeters of 70 per cent urokon sodium was manually injected. The aortogram, which was satisfactory, showed neither an aneurysm nor significant occlusion (Fig. 5). The urine, which had previously been normal, contained red blood cells and protein. The blood urea nitrogen level rose from 16 milligrams per 100 cubic centimeters to 105 milligrams per 100 cubic centimeters by the end of 1 week. These abnormal findings gradually resolved during the succeeding 2 weeks and the patient has remained well.

CASE 3. R. D. B., a man 37 years old, was admitted because of intermittent claudication and impotence of 3 years' duration. The only significant features of the physical examination were diminished pulses throughout both lower extremities and findings consistent with a congenital interventricular septal defect. Blood counts, urinalysis, and the blood urea nitrogen level were normal. Two days after admission following anesthetization with pentothal sodium, a No. 17 thin needle was introduced through the back toward the aorta opposite the twelfth dorsal vertebra. The characteristic pulsatile blood flow was obtained and 15 cubic centimeters of 70 per cent urokon sodium was injected manually. The roentgenogram showed the needle in juxtaposition to the orifice of the right renal artery (Fig. 6). This artery and the right kidney were brilliantly outlined. A satisfactory aortogram was obtained showing partial occlusion of both common iliac arteries. Urinalysis following aortography revealed protein and microscopic hematuria, but the blood urea nitrogen level remained normal. Two days following aortography ureteral catheters were inserted and divided differential renal clearance studies were carried out. They indicated normal function on the left and essentially no function in the right kidney (Fig. 7). Operation was postponed to permit possible recovery of function in the right kidney. At the present time, 3 months after aortography, the patient has no urinary abnormalities and intravenous pyelography shows reduced and delayed, but definite, concentration and excretion of contrast medium by the right kidney (Fig. 8).

In all 3 patients renal function was normal prior to aortography, but acute renal damage became evident immediately after the procedure. At autopsy the kidneys of the first patient showed the characteristic destructive parenchymatous changes usually observed in

FIG. 2. Photograph of the external surface of the kidneys in Case 1 showing the characteristic gross appearance. Note the multiple hemorrhagic areas in the right kidney.

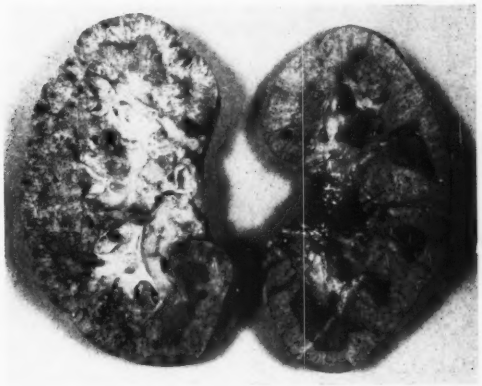

FIG. 3. Photograph of a cross section of the kidneys in Case 1 showing the hemorrhagic areas in both kidneys, more pronounced in the right.

patients dying following this complication. The constant factor in these patients was a heavy concentration of urokon sodium in the kidneys as a result of large doses in the first 2 patients and direct injection of the renal artery in the other patient.

NEUROLOGIC COMPLICATIONS

Reports of 13 cases of paraplegia following aortography have appeared in the literature. The available information regarding these cases, which is inadequate for analysis, has been summarized in Table V. Only 1 patient completely recovered, 4 died and recovery was only partial in the remaining 5 cases in which this information is available.

No neurologic disturbances occurred in our series although there was 1 patient with pain in the distribution of the genitofemoral nerve after aortography performed elsewhere. In this patient a local anesthetic was used and during insertion of the needle, the patient felt intense pain in the distribution of the genitofemoral nerve but there was no evidence of muscular weakness. This pain gradually diminished during the next few weeks, and at the time we saw him it had almost subsided. It is our impression that the pain in this case was caused by direct trauma to the nerve as occasionally occurs during and after spinal anesthesia.

THROMBOSIS AND EMBOLISM

Thrombosis of the aorta has not been reported as a complication of aortography; however, thrombosis of the superior mesenteric artery has occurred in 4 patients, and thrombosis of the inferior mesenteric artery proved at operation has been observed in 1 patient (Table I). All patients who had thrombosis of the superior mesenteric artery died of intestinal infarction whereas in the patient with thrombosis of the inferior mesenteric artery the diagnosis was made incidentally at operation upon the aorta. Direct arterial injection of contrast medium into the respective artery was inadvertently per-

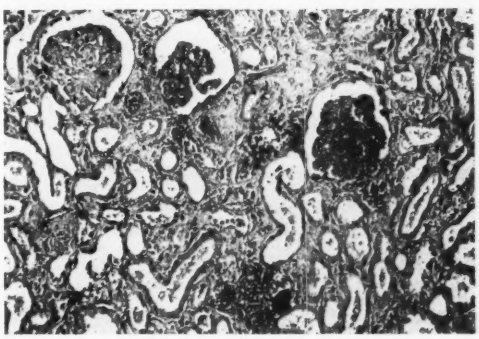

FIG. 4. Photomicrograph of the right kidney in Case 1 showing interstitial hemorrhages and glomerular and tubular destruction.

FIG. 5. Aortogram in Case 2 showing a tortuous aorta with an unobstructed lumen.

formed in all 5 instances, 80 per cent sodium iodide being used in those with thrombosis of the superior mesenteric artery and 70 per cent urokon sodium in the patient with thrombosis of the inferior mesenteric artery. Direct injection of sodium iodide into these arteries without complication has not been reported; however, direct injection of the celiac axis, splenic, hepatic, lumbar, and superior mesenteric arteries with 70 per cent urokon sodium or 70 per cent diodrast® has been performed on a number of occasions without significant complication. It would appear, therefore, that direct arterial injection of contrast medium predisposes to thrombosis and that the incidence of this complication is considerably greater with the use of sodium iodide or other inorganic iodine compounds.

Two cases of embolism have been reported. In one the embolus consisted of an arteriosclerotic plaque which caused gangrene and loss of an extremity. Embolization occurred in the other patient some time after aortography and was thought to have consisted of a thrombus that originated at the site of aortic puncture. This embolus was successfully removed from the bifurcation of the aorta, and the patient was not otherwise adversely affected (Table I).

MISCELLANEOUS

Chylothorax from a tear of the thoracic duct in the region of the diaphragm controlled by operation has been reported once. The most unusual complication is that reported by Joyeux and associates whose patient passed rectally 3 segments of gangrenous large intestine with spontaneous recovery.

Iodinism characterized by nausea, vomiting, rash, bronchitis, lacrimation, salivation, and depression of the central nervous system has also been reported and in all cases after use of sodium iodide. This complication was mild in most cases, the only fatality being the one reported by dos Santos and co-workers. Simple urticarial reactions are not usually reported as complications; in our experience they have been relatively rare after use of urokon sodium and are of no consequence. Pendergrass and associates (31, 32) attempted to evaluate the incidence of allergic reactions to the intravascular injection of contrast medium by means of questionnaire. They found reports of 31 deaths in approximately 3,800,000 collected cases of excretory urography. Accordingly, significant allergic complications would appear to be relatively rare.

DISCUSSION

A critical analysis of the material presented suggests, in the light of present clinical knowledge and certain available laboratory data, that in most instances complications have resulted from aortography primarily because of violations of certain basic principles in the application of the procedure. Common among these have been errors in selection of patient, choice of contrast medium, amount of this substance injected, site of injection, or technique of injection. Since

FIG. 6. Aortogram in Case 3 showing the point of the needle within the opening of the right renal artery and a brilliantly outlined right kidney. Note the bilateral partial occlusions of the iliac arteries.

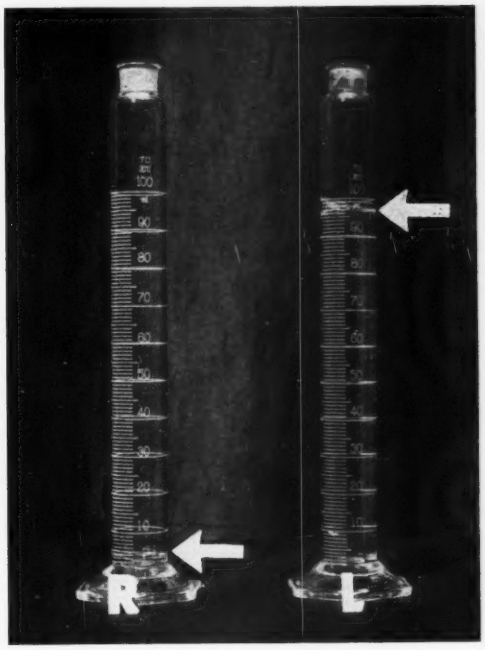

FIG. 7. Photograph of a 10 minute period of urine collection after overhydration of the patient; 96 cubic centimeters of urine were excreted by the left kidney in contrast to 3 by the right kidney in this 10 minute period.

the operator has control of these variables to a large extent, most of these complications would appear to be preventable. Accordingly, each of these facets of aortography will be discussed separately.

Selection of patient. The indication for aortography is not clear in the majority of the reported cases with complications. A review of our own series of cases, however, in which complications followed aortography, would suggest that in approximately 60 per cent of them the procedure was not required according to our present knowledge of the indications for aortography. In our early experience it was thought that all patients with either aneurysms or thrombo-obliterative lesions of the abdominal aorta and iliac arteries should be studied by aortography in order to ascertain the location and extent of the lesion as well as the condition of the distal vessels. With increasing experience, however, it soon became obvious that this procedure was unnecessary in the majority of cases for these purposes. Correlation of the aortographic findings and clinical manifestations with the pathologic features revealed that these diseases assumed certain characteristic patterns that were recognizable from clinical manifestations alone. In aneurysms of the abdominal aorta, for example, it was found that in the great majority of instances the lesions arise below the origin of the renal arteries. This is well substantiated by the fact that in our surgical series of 280 aneurysms of the abdominal aorta, only 12 involved the segment of aorta from which the major abdominal visceral arteries arise and only 2 of these were truly abdominal aneurysms, the others being thoracoabdominal in location. This observation, along with the demonstration that involvement of the renal as well as the other major abdominal arteries by the

FIG. 8. Photograph of an abdominal roentgenogram taken 15 minutes after 30 cubic centimeters of 30 per cent urokon sodium was injected into the antecubital vein. Good concentration and excretion of the contrast substance is demonstrated in the left kidney. This function, even though present, is considerably reduced in the right kidney.

aneurysm no longer constitutes a contraindication to operation, has eliminated the necessity for aortography in the preoperative evaluation of this lesion either for purposes of diagnosis or surgical approach (9).

In arteriosclerotic occlusive lesions of the aorta, the disease has been found to assume two general patterns, namely, complete and incomplete occlusion. Slightly less than half of our series of about 215 cases were in the former group. Particularly significant is the fact that in all of these patients with complete occlusion of the aorta, patent arterial segments distal to the occlusive process to which anastomoses could be made were found. This constant observation along with the fact that this lesion is readily recognizable by its clinical manifestations, including particularly the absence of femoral pulsations, has led us to discontinue the use of aortography as unnecessary under these circumstances. In patients with incomplete aortic occlusion, however, the pattern is less constant, and considerable variations exist in the extent and nature of the occlusive process with a common tendency for segmental obstructions in the distal arterial bed. Under these circumstances aortography may be useful in providing more precise information concerning the site and extent of involvement for planning the proper surgical procedure.

Thus, on the basis of our experience with almost 500 cases of aneurysms and occlusive lesions of the abdominal aorta, it would appear that there are relatively few indications for aortography in the surgical management of these diseases. Aside from those patients with incomplete occlusive disease of the aorta, the procedure may sometimes be indicated in cases in which the diagnosis is doubtful. A patient is occasionally seen, for example, who has intermittent claudication and reasonably normal or only slightly diminished peripheral pulses, but in whom partial obstruction of the iliac arteries is demonstrated by aortography. Under these circumstances aortography is necessary in order to exclude other diseases causing symptoms in the legs and to establish the diagnosis. For similar reasons it may be occasionally indicated in patients with a doubtful diagnosis of aneurysm of the abdominal aorta. Thus, we have observed 5 patients suspected of having an abdominal aneurysm, but owing to obesity, this could not be determined by physical examination or by plain roentgenograms. Aortography revealed that 2 of these patients did have aneurysms which subsequently were successfully removed.

It is important that the patient's general condition does not contraindicate operative treatment, because otherwise the procedure contributes little to the patient's recovery. Bleeding tendencies and other abnormalities that invite complications must be recognized before the study is performed. Aneurysmal puncture has been performed several times without complication, but severe bleeding occurred afterward in the case of McAfee and Willson and in 1 of our patients. Multi-

TABLE V.—AVAILABLE DATA ON 13 CASES OF PARAPLEGIA FOLLOWING AORTOGRAPHY COLLECTED FROM THE LITERATURE

Author	*Contrast medium*	*Total volume, c.c.*	*Injections*		*Result*
			No.	*Site*	
Abeshouse *et al.*	70% urokon	32	2		Partial recovery
Antoni *et al.*	70% diodrast			L_1	Death
Baurys					Death
Boyarsky	70% urokon	15	1	L_2	Partial recovery
Crane	70% urokon	80	2	L_1	Partial recovery
Deterling (11)	70% urokon	20			Recovery
Edwards	70% urokon	10			Death
Evans					—
Evans					—
Evans					—
Evans					—
McCormick	70% urokon	35	2		Death
Nelson					—

ple aortic puncture in the former and a prolonged clotting time in the latter were undoubtedly significant factors.

Choice of contrast medium. All of the significant systemic reactions to iodine have been reported following use of sodium iodide. Direct arterial injection of this inorganic compound has invariably resulted in damage of the organ supplied by that artery, and renal complications have resulted from much smaller doses of this substance than organic iodides. Direct arterial injection of organic iodides has not produced injury of any organ except the kidney and only minimal systemic reactions have been observed. Urokon sodium in doses of 25 cubic centimeters or less has produced no undesirable effects in our series of 200 aortograms in which this dose was employed except in the 1 patient with direct injection of the renal artery. Differential renal function studies in 25 patients before and after aortography have shown that this amount of urokon does not affect renal function (8). This substance is therefore considered harmless when used in the prescribed dosage range.

Contrast medium dosage. Differential renal function studies including glomerular filtration rate and renal plasma blood flow, performed in our laboratory on patients subjected to aortography, show reduction of renal function in 50 per cent of patients who received more than 40 cubic centimeters of urokon sodium. Renal function was unaltered in those patients who received 25 cubic centimeters or less of urokon sodium, even in the presence of renal damage or varying degrees of aortic occlusion (8). It is highly significant in this regard that all patients reported to have had renal injury, including our own, had either sodium iodide or 40 cubic centimeters or more of an organic compound. Several patients in the review and one-third of our patients with bilateral injuries received at least 2 injections of such doses. In our experience 15 to 25 cubic centimeters of 70 per cent urokon sodium has been adequate and safe for excellent aortography, and by proper utilization of equipment and timing, the abdominal aorta and the major vessels of the lower extremities can be satisfactorily visualized. Therefore, larger amounts are unnecessary and potentially harmful, particularly if given in multiple injections.

We have had no experience with neurologic disturbances following aortography in human beings and considerable information is lacking in the reported cases. The level of paralysis has been between the eighth and eleventh dorsal segments at which levels a major spinal cord artery frequently originates. Reflux is often seen at these levels when a large volume (50 c.c.) of medium is injected into the abdominal aorta, especially if delivered under great pressure. This result does not occur with smaller doses delivered manually. Furthermore, it is of interest that convulsions have developed in the dog's hind quarter when a larger volume of iodide was injected (8). It would appear, therefore, that dosage of contrast medium and pressure of

injection are significant factors in the production of such disturbances, particularly since large doses of iodides in multiple injections or injected under high pressure were constant factors in the clinical cases in which this information was available.

The experiments of Tarazi and associates demonstrate conclusively the toxic effects of urokon upon the spinal cord of dogs. The region of injury in many cases apparently was greatest at the level of injection and varied somewhat with the dosage. These data, however, are difficult to translate into clinical terms since the canine spinal cord extends much lower than the human and has greater contact with the contrast medium injected at the ordinary level for aortography. Animals injected in the prone position (the position in which clinical aortography is performed) apparently escaped injury.

Technique and site of injection. Errors in technique have been responsible for a considerable number of the complications of aortography. All cases of serious hemorrhage have been associated with multiple aortic punctures or change in position of the patient while the needle is in place. Extravasation of contrast medium and multiple punctures of the aorta have been the constant factors in the production of troublesome pain during or after the procedure. Direct injection of a vital aortic branch has been shown to be associated with injury of the organ perfused with the contrast medium. Small doses of urokon that are ordinarily safe for aortography when injected directly into the dog's renal artery have, in our experience, invariably produced severe damage to the kidney. It would appear essential, therefore, to pierce the aorta only once (thereby excluding the two needle technique and increasing the demand for precision). The needle should enter the aorta at a level to prevent direct injection into a vital artery. This could be theoretically more safely accomplished by injecting below the renal arteries since the major abdominal branches arise above this level. This is impractical, however, because occlusive lesions frequently arise at or extend up to the renal arteries and, secondly, the relationship of the major arteries to an aneurysm may be the indication for the study in the first place. Consequently, it will be necessary to inject above these vessels in most instances and this can be accomplished by piercing the aorta opposite the twelfth thoracic vertebra. Proper placement of the needle can then be ascertained by a preliminary roentgenogram after 5 cubic centimeters of the contrast medium has been injected.

SUMMARY

1. A review of the literature and our own experience with 300 aortograms reveals the following complications of aortography: pain, hemorrhage, thrombosis and embolism, renal insufficiency, neurologic changes, allergic reactions, and other systemic disturbances that may be related to the use of general anesthesia. Although the incidence of these complications is relatively small, their significance in some instances is great since they may produce permanent disability and even fatal consequences.

2. Analysis of this material along with certain experimental observations suggests that in most instances the responsible factors for these complications are errors in selection of patient, choice and dosage of contrast medium, and technique of injection. Since these are controllable variables, most of these complications should be preventable.

3. In the selection of patients for aortography its indications for purposes of diagnosis and surgical approach deserve careful consideration. In the great majority of cases of aneurysms of the abdominal aorta, for example, there is little or no need to perform aortography for these purposes. Similarly, in complete occlusive disease of the aorta, aortography has been found unnecessary for these purposes. Its usefulness lies primarily in patients with incomplete aortic occlusion and in the few patients in whom the diagnosis remains doubtful. Accordingly, and from an analysis of our experience, the necessity for aortography may be eliminated in the majority of patients with aneurysms and oc-

clusive disease of the abdominal aorta, approximately two-thirds of the cases, with commensurable reduction in the occurrence of complications.

4. Multiple aortic puncture and extravasation were responsible for the cases of hemorrhage and troublesome pain. Kidney damage was associated either with direct injection of the renal artery, use of inorganic iodide compounds, or injection of excessive contrast medium. Other miscellaneous complications appeared to result from lack of technical precision or use of inorganic iodide.

5. Consequently, certain principles in technique are suggested. The aorta should be pierced only once, well above its major abdominal branches, and only 15 to 25 cubic centimeters of an organic form of iodide should be manually injected after a preliminary roentgenogram has been made following injection of 5 cubic centimeters of medium to ascertain accurately the position of the needle.

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A DESCRIPTION OF THE BOUNDARIES OF THE INGUINAL RINGS AND SCROTAL POUCHES

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IT IS NOTEWORTHY that but scant attention has been directed to the anatomic rings of the inguinoscrotal region. Most inguinal hernias pass through one or more of these rings, having been preceded in the fetal state by the descending testis. It is the purpose of this paper to classify and to redefine the boundaries, and evaluate the rings of the inguinoscrotal region in the light of our cumulative knowledge of hernia. This discussion will include the correlative anomalies which obtain in connection with the descent of the testis to the scrotal pouch. Most textbooks of anatomy describe 3 inguinal rings, the abdominal or internal, the aponeurotic or external, and the femoral ring. The latter, although extracanalicular, is so intimately related clinically and anatomically to the former that it seems logical and practicable that it be included in the classification of the rings of the inguinoscrotal region.

Every surgeon is familiar with the anatomic boundaries and location of these 3 rings. There have been differences of opinion, chiefly about the exact functional mechanism of the internal ring, which have not been completely reconciled. In analyzing the background for these persistent differences, it would seem that they arise chiefly from failure to state explicitly whether the functions attributed to the internal ring are exclusively those of a normal or a dilated ring and whether they are controlled by an intrinsic sphincter. It is the general consensus that the effectiveness of the shutter-like action of the ring is in inverse proportion to its degree of dilatation. If arcuate fibers of the transversus abdominis muscle are present they may produce some contractility, possibly augmented by the overlying internal oblique muscle.

Superimposing further confusion there have been described 3 additional rings of the spermatic canal: (a) the middle inguinal, which is surrounded by the transversus abdominis fascia and aponeurosis; (b) the intermediate, which is a derivative primarily of the obliquus internus muscle; and (c) the inguinoscrotal, which is traceable to the conjoined and concentric arrangement of 3 fascias; Colles', Camper's, and Scarpa's of the perineoinguinal region. This latter series of anatomic rings may become so distorted by the herniating mass that one ring through the process of dilatation may merge into the subadjacent one, often making it difficult to distinguish them clinically. They are of anatomic and embryonic significance. Knowledge of them contribute to a better understanding of the combined murosaccular weakness, which often confronts the surgeon at operation.

THE ABDOMINAL OR INTERNAL RING

The abdominal or internal ring (Fig. 1) is the first parietal hiatus through which the testis and its gubernaculum must pass in their downward retroperitoneal descent to the scrotum. This ring is bounded exclusively by conically arranged fascia transversalis which is closely applied to the spermatic cord. Most authorities agree that the ring initially is round or oval in shape and that its inferomedial fascial arc is the most vulnerable. It is this portion of the ring which yields to the expotential pressure of the hernia. A piston-like action may go on, resulting in subsequent dilatation and distortion from an initially round or oval hiatus.

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ultimately to a dilated U-shaped ring. The internal ring lies in a plane oblique to the long axis of the inguinal canal.

The competency of the internal ring, according to Lytle, depends upon the dual action of the transversus abdominis and the obliquus internus muscles; the former raising the position of the ring a few millimeters laterally and superiorly, the latter forming a lid over the aperture, which may possibly be implemented by the tautened external oblique aponeurosis. This combined and co-ordinated muscular contraction produces a sliding valve effect. However, the degree of movement of the ring is directly related to the ratio of the fascicular to the aponeurotic component of the transversus abdominis muscle. Similarly, the completeness of its closure is dependent upon the extent of the annular dilatation. Another protective phase has been postulated in the functioning of this complex mechanism of the ring which presumably augments its physiologic action. This phase is based upon the observations of Liddell and Sherrington, that a stretch applied to a muscle in its contractile state further enhances its contraction to a considerable degree. This phenomenon has been designated the stretch reflex.

The foregoing functional actions of the internal ring are predicated on normally developed musculature, which often do not obtain in those suffering from hernia. Anson and his associates have called attention to the structural variations of the parietal strata. It follows that voluntary movements of the internal ring would be appreciably diminished in those individuals having hypoplasia of the transversus abdominis and could conceivably reach the point in which the contractile force is not sufficient to compensate for the lag due to the weakness or dilatation of the ring. In this event, there would not be a reduction to the normal dimensions of the abdominal ring; in effect, the ring would be functionally inert. Weakness of the internal oblique muscle may further cripple the function of this ring by decreasing the protrusional resistance offered by this muscle.

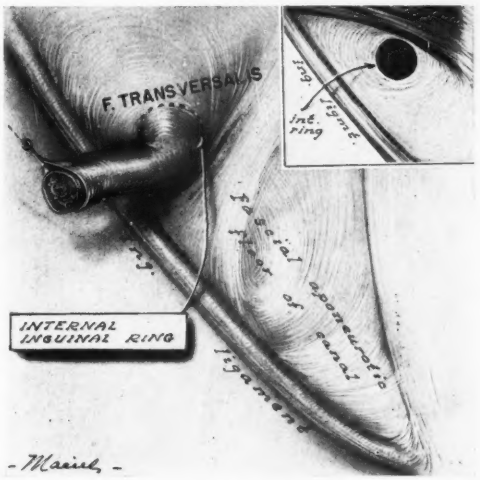

FIG. 1. The internal inguinal ring is indicated by the dotted circular line. The fascia transversalis forms its boundary and closely surrounds the exit of the spermatic cord. The inset shows a round ring with the inferior margin of the transversus abdominis muscle adjacent to the superior arc of the ring.

Therefore, it should be emphasized that in a large dilated ring, particularly if associated with adjacent structural weakness, there is probably little or no actively functioning musculature of the internal ring. We believe as others that this ring has no sphincter.

Based upon these functional concepts of the abdominal ring, the surgeon is provided a better understanding of the rationale for the initial development of two major standard operative repairs, one (herniotomy) which is intrinsically related to retaining or re-establishing the function of the internal ring; and the other (herniorrhaphy) which is directed toward additively reinforcing the posterior wall of the inguinal canal with coincidental tautening of the ring. In the latter operation it is assumed the ring is noncontractile.

THE MIDDLE INGUINAL RING

The middle inguinal ring (Fig. 2) is caudal to the internal ring, which it surrounds like a collar. It is twice the size of the internal ring. It is bounded cephalad by the inferior fascicular margin of the transversus abdom-

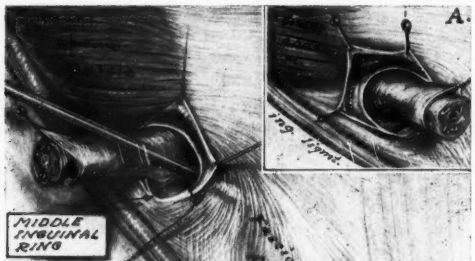

FIG. 2. The middle inguinal ring is medial and subjacent to the internal ring. The anterior and posterior fascial coverings of the transversus abdominis muscle are shown conjoining to form the boundary of the ring. Insets A and B illustrate the action of the transversus abdominis muscle in producing one component of its sliding valve action.

inis; inferomedially and inferolaterally it is limited by the conjoined anterior and posterior fascial envelope of the transversus abdominis muscle. The caudal half of the ring corresponds to the lateralmost margin of the posterior wall of the inguinal canal. The fusion of the lateral expansion of the interfoveolar or lateral ligament of the floor of the canal with the conjoined fascias of the transversus abdominis muscle strengthens this common boundary margin. The ring in its normal state is U-shaped. Its vertical boundaries are exclusively fascial and acting as slings. The middle ring like the internal contains no intrinsic fascicular fibers and consequently has no sphincteric action. The fascias forming the inferior boundary of the middle ring continue inferomedially, entering into the formation of the femoral arch and subsequently emerging with the psoas-iliacus fascia.

It seems paradoxic that an anatomic inguinal ring of its constancy, with such distinct fascial boundaries, and which is the most important of the inguinal rings clinically and surgically, is relatively unknown by this identity to most surgeons. However, in retrospect, there does seem to be valid explanation for this apparent incongruous situation. By comparison, the internal ring is small, its boundaries are less distinct, and the fascia transversalis is draped closely around the exit of the cord. Contrary to prevailing opinion, a normal internal ring rarely obtains in the presence of an indirect hernia. Consequently, the surgeon is seldom afforded the opportunity of seeing a normal internal ring. Actually, the ring which is exposed at operation is the middle ring. Almost invariably the internal ring has become dilated and as a result now conforms to the dimensions of the middle ring.

THE INTERMEDIATE INGUINAL RING

Just as the internal ring is an aperture through the deepest parietal stratum, the fascia transversalis, and the middle ring is surrounded by the fascioaponeurotic elements of the transversus abdominis which is the second parietal stratum, so the intermediate ring (Fig. 3) is predominantly derived from the obliquus internus muscle or third parietal lamina. The intermediate ring differs morphologically from the heretofore described rings in that it is infundibuliform and more elongated. Its anterior boundary is wholly muscular which explains the demisphincteric action of the ring. If the arcuate fibers assume a direction paralleling that of the canal, there is additive propensity to shortening as well as narrowing of this segment of the canal. The posterior boundary of this obliquely placed orifice is the fascia transversalis and the conjoined aponeurosis. Because of frequency of anomalies in the development of the obliquus internus muscle, this ring is subject to considerable variation in its function. Another long recognized departure of this muscle is the inconstant level of its insertion onto the sheath of the rectus from the pubic spine. The higher its insertion the larger the medial inguinal triangle, consequently the greater the liability to weakness and herniation.

The functions of this intermediate musculofascial ring are to act as a taut protective buffer or lid superimposing the midportion of the canal and through its contractile state to reduce the anteroposterior diameter of the inguinal funnel. Morgan and Anson referred to the existence of the intermediate ring but did not clearly define its boundaries. The obliquus internus in its relaxed state forms a loose anterior investment of the spermatic cord. The reduplicated fascia transversalis with conjoined aponeurotic reinforcement constitutes the posterior counterpart of the intermediate ring. Consequently, the internal oblique stratum in the strictest sense does not possess a wholly circumscribed fascicular orifice. When there is hypoplasia, or what more frequently happens, protracted stretching of the fibers of the internal oblique, there results a progressive dilatation of the intermediate ring by the herniating mass. When this chain of events obtains, it can be assumed that the effectiveness of the ring is concomitantly diminished because of weakness of its sphincteric action. The objective

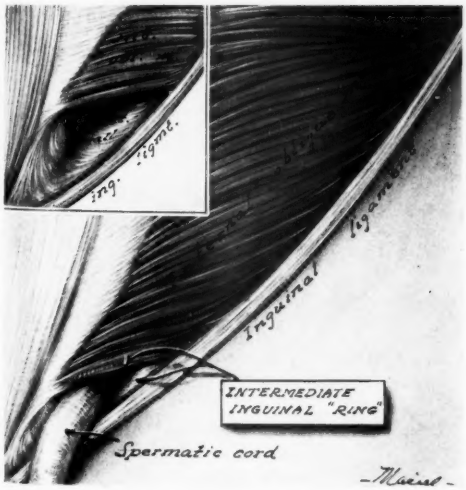

FIG. 3. The intermediate ring is an elongated oval with the fascicular portion of the internal oblique muscle contributing the anterior boundary and the posterior fascial wall of the spermatic canal its posterior boundary. Contraction of the internal oblique fibers narrows the ring with some concomitant shortening of the fascicular portion of the canal.

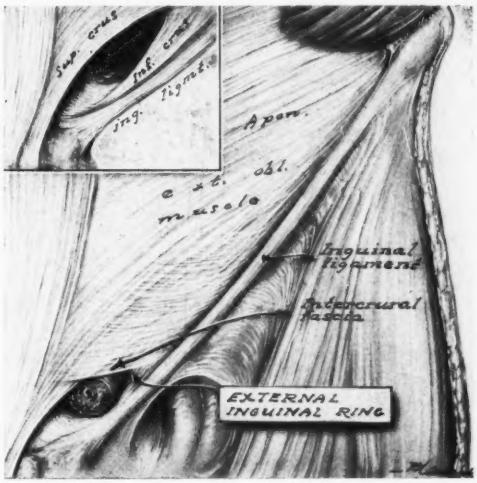

FIG. 4. The external inguinal ring is fascioaponeurotic. Contraction of the external oblique muscle does not alter the relationship of the superior and inferior crus. Consequently the ring is considered inert.

of the operations which have been devised to correct diminution in its muscular tone has not been directed primarily toward regaining the contractile function of the ring but more to attaining greater unyielding structural security of the wall. This direct support is achieved best by approximating fascia to fascia, since the union of the flimsy connective tissue surrounding the muscle fibers to fascia is less secure.

THE EXTERNAL OR APONEUROTIC RING

That portion of the obliquus externus muscle caudal to the anterior superior spine of the ilium is exclusively aponeurotic (Fig. 4). This component of the muscle forms one stratum of the anterior boundary or roof of the inguinal canal and continues inferiorly as the inguinal ligament. Similarly, that portion of the aponeurosis overlying the caudal end of the inguinal canal splits into a triangular cleft for the exit of the testis and cord. The superior and inferior crura of the cleft insert into the symphysis pubis and the spine of the pubis, respectively. The triangular rent may measure 4 centimeters in length from its base to its apex. The inter-

FIG. 5. The relationship of the inguinoscrotal ring to the external ring is shown in the adult. The lower abdominal wall is reflected so as to visualize Scarpa's and Camper's fascia.

crural fascia, which is derived from the fascial envelope of the external oblique muscle, converts the apex of the fault in the aponeurosis into a ring surrounding the exit of the cord.

There is much controversy as to what dimensional standard constitutes a normal ring. Clinically, it is pretty well agreed that a normal external ring should admit the tip of the index finger but with the pillars surrounding it snugly. Any greater annular diameter is usually considered a relaxed, an abnormally enlarged, or a dilated ring. There has been divergence of opinion as to the interpretation of the clinical significance of an enlarged external ring as a criterion for the diagnosis of hernia or potential hernia. For instance, careful measurements of the external ring in a large series of males have shown an incidence of dilatation varying from 6.85 per cent (Tobias) to 78.8 per cent (Chassin). Ferguson and Wolcott who reported their findings on 4,000 men had a 9.8 per cent incidence of enlarged rings. The latter group was followed for from 9 to 11 years; in 5.1 per cent of those patients with relaxed rings, hernias developed, whereas, hernias developed in only 2.9 per cent of those with normal rings. The authors considered this difference not statistically significant. In general, it is the consensus that the size of the external ring in an individual who has a taut posterior wall plays no appreciable etiologic role in the development of hernia. However, there are some physicians who hesitate to accept the conclusions drawn from these statistical studies and believe that an enlarged external ring represents a potential liability to herniation.

THE INGUINOSCROTAL RING

In the event the testis has been successful in negotiating its passage through each of the 4 preceding rings of the inguinal canal, which occurs about the eighth month of fetal life, it should now be poised at the entrance to the inguinoscrotal ring, which is the last hiatus through which it must pass before reaching the scrotum (Fig. 5). This

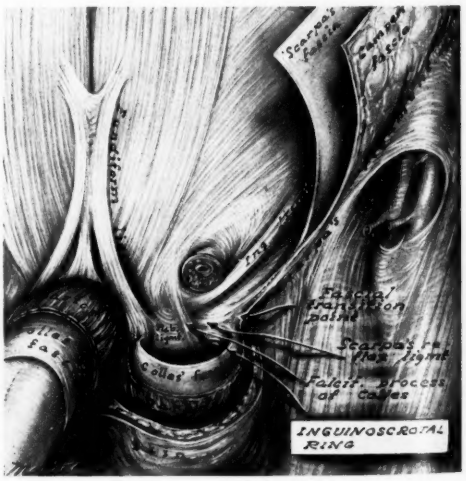

FIG. 6. The fascial boundaries of the inguinoscrotal ring are depicted. There is also shown the funiform, pubic, and Scarpa'a reflex ligaments. The relationship of Scarpa's, Camper's, and Colles' fascias are important in the proper understanding of its formation and the anomalies that may obtain in connection with this ring.

ring is located about 2 centimeters caudal to the external inguinal ring in the adult but is immediately adjacent in the fetus. It is oval in shape provided Scarpa's ligament is present which forms its lateral boundary or crus. In those cases in which the reflected process of Scarpa's fascia does not form a well defined ligament the ring is incomplete laterally with the opening becoming funnel shape in its horizontal plane.

This ring was previously described by McGregor. It is bounded anteriorly by the continuation of Scarpa's into Colles' fascia, Camper's fascia and dartos; posteriorly, by the pubic ligaments overlying the superior pubic ramus adjacent to the symphysis; laterally, by Scarpa's reflex ligament, the falciform process of Colles' and the direct scrotal attachment of Scarpa's fascia; medially, by the fundiform ligament and the root of the penis (Fig. 6). All important is the patency of the ring during the descent of the testis. This is maintained by many diminutive supporting ligamentous bands which arise from the external oblique aponeurosis adjacent to the external ring and insert into the anterior arc of the inguinoscrotal ring.

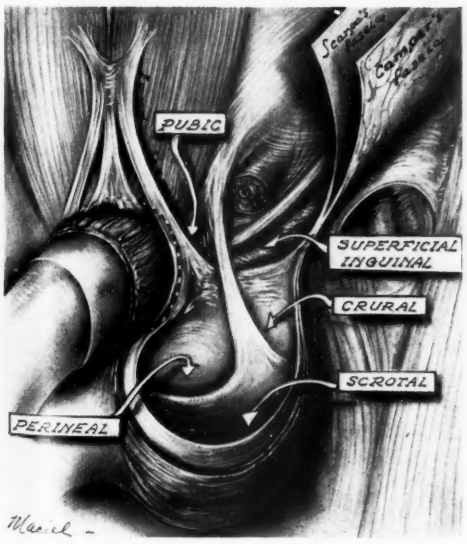

FIG. 7. The inguinoscrotal pouches have been diagrammatically outlined. The importance of the falciform process and the perineoscrotal reduplication in the descent of the testis is emphasized.

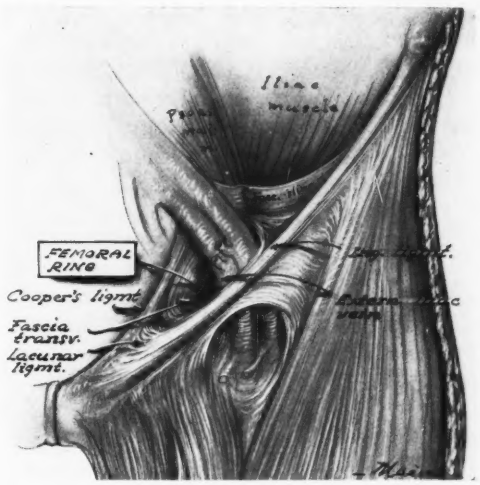

FIG. 8. The femoral ring is closely related to but inferior to the inguinal canal. A femoral sacculation arises from the direct component of the inguinal hernia. The vulnerability of the ring to herniation is influenced by the development and extent of the lateral margin of the lacunar ligament.

All rings of the spermatic canal have in common an embryonic function but the function of the inguinoscrotal ring differs from the others in that its function is exclusively prenatal. It directs and guards the descent of the testis, so that it may follow the normal pathway into the scrotal pouch. There are 5 anatomic pouches (Fig. 7) in and about the genital region; the pubic, superficial inguinal, crural, perineal, and the scrotal. Consequently, after the testis has cleared the inguinal canal it is still exposed to the hazard of being deflected into one of these pouches other than its normal resting place, the scrotal.

Imperfect descent of the testis is attributable to: (1) congenital anomalies of the testis, gubernaculum, or absence of the inguinoscrotal ring, (2) congenital anomalies of the fascial pouches, and (3) congenital anomalies of the fascial reduplications or ridges. In the event that the inguinoscrotal ring is narrowed and collapsed, the testis having reached this level of its descent is

SUMMARY OF ANATOMIC RINGS OF INGUINOSCROTAL REGION

Classification	*Boundaries*	*Function*
1. Internal inguinal ring or fascia transversalis ring	Fascia transversalis exclusively, arranged circumferentially around spermatic cord	Slide valve action of undilated ring Variable contractile function of transversus abdominis in proportion to arcuate fibers
2. Middle inguinal ring or transversus abdominis ring	Conjoined fascias and the aponeurosis of transversus abdominis muscle In dilated internal rings the f. transversalis becomes an additional boundary	No pinchcock effect No contractile function Inferomedial arc more vulnerable
3. Intermediate inguinal ring or obliquus internus ring	Anteriorly by obliquus internus muscle Posteriorly by triple fascial strata and conjoined aponeurosis	Semisphincteric action producing narrowing of canal Directional contraction consonant with arrangement of muscle fibers
4. External inguinal ring or obliquus externus ring	Aponeurosis of obliquus externus Intercolumnar fascia	Resists progress of hernia No voluntary action Lesser barrier to oncoming herniation
5. Inguinoscrotal ring or conjoined inguinoscrotal fascial ring	Anteriorly by continuation of Scarpa's fascia into Colles' fascia Posteriorly by the pubic ligaments overlying the superior pubic ramus adjacent to the symphysis Laterally by the falciform process of Colles', Scarpa's reflex ligament and indirect scrotal attachment of Scarpa's fascia Medially by the fundiform ligament and root of penis	Prenatal only, by maintaining the gateway to scrotum Stenosis or absence may cause ectopic testis Clinically important in relocating ectopic testis The dartos, reportedly has some suspensory action
6. Femoral ring	Anteriorly by inguinal ligament Posteriorly by Cooper's ligament, superior pubic ramus and pectineus m. Laterally by septum of f. transversalis interposed between ring and ext. iliac vein Medially by lacunar ligament	Inert Medial boundary most vulnerable Eccentrically placed to inguinal canal Femoral hernia coexists with direct hernia

situated in the inguinoscrotal space where it may be diverted either medialward or lateralward but remain in the same horizontal space. Should it migrate medialward it becomes arrested in the pubic pouch. This fossa lies over the symphysis with the reflected fundiform ligament forming its anterior boundary; the pubic ligaments and base of penis, the posterior and medial boundaries respectively. Incidentally, this is the rarest form of ectopia. The other alternative direction which the testis may take at this level is lateralward along the gutter formed by the fusion of Scarpa's fascia with the fascia lata and the inguinal ligament, continuing in this direction until it reaches the superficial inguinal (interstitial) pouch. This pouch is covered by the superficial fascia of the anterior abdominal wall.

If there is no interruption to the passage of the testis through the inguinoscrotal ring, its progress may be arrested in the superior or cervical portion of the scrotum. Should the testis descend medial to the falciform process of Colles' fascia it may take a posterior direction until it reaches the perineal (superficial) pouch. However, should the testis enter the upper scrotum lateral to the falciform process it becomes deflected lateralward to the crural pouch. The testis may be prevented from entering the scrotal pouch by a congenitally overdeveloped perineoscrotal fascial reduplication which may form a ridge-like elevation acting as a barrier to the further descent of the testis.

According to Keith the upper part of the inguinal canal is imperfectly closed at the third month after birth in 30 to 40 per cent of children. Wrisberg found that 30 per cent of newborn male children have undescended testes. However, in most of these, descent is completed in the first few weeks after birth. DaCosta reported 1 person out of 100 had either an undescended or ectopic testis. The War Department found some type of maldescent or testicular anomaly in 3.1 per 1,000 males examined. Therefore, the inguinoscrotal ring is not only important embryologically during fetal life but the surgeon may encounter an undescended or ectopic

testis in infancy or later life. Consequently, familiarity with the various pathways the testis may take can be important in dealing with the malplaced testis. Almost invariably, imperfect descent of the testis is associated with a hernia. In pubic or superficial inguinal ectopia the testis should be returned to the point of departure from its normal pathway and then a pathway to the scrotal bed should be established. If a perineal or crural ectopia obtains, the testis is returned to the scrotal isthmus and then directed to the scrotal pouch.

THE FEMORAL RING

The femoral ring (Fig. 8) is inferomedial to the internal and middle anatomic rings of the inguinal canal. Because of this contiguous relationship at the infundibuliform entrance to the inguinal canal and since a femoral locule is a variant of a direct hernia sac, it would seem clinically appropriate to include the femoral ring in a discussion of the multiple rings of the inguina. Incidentally, Fauntleroy reported having observed 1 instance in which the testis and cord descended through the femoral ring and proceeded to a scrotal destination.

The femoral ring is a round or slightly oval aperture, which may vary in size from a small fovea to a well defined orifice 1.5 to 2 centimeters in diameter. It is situated in the lateral portion of the interligamentous space which is also in the middle inguinal fossa. The fascia transversalis lines the orifice with the external iliac vein lying laterally adjacent to it. The lateral edge of the lacunar ligament forms its medial boundary. Anteriorly, the inferior edge of the inguinal ligament limits the ring; its posterior boundary is Cooper's (posterior iliopubic) ligament. The superior pubic ramus and the pectineus muscle are often included as components of the posterior boundary.

The vulnerable portion of the femoral ring is its medial arc. This weakness has been ascribed to attentuation or aplasia of the medial lacunar ligament. One factor which has been postulated in explaining the mechanism of the dilatation of this ring is the distention of the external iliac vein which is possible but not likely. Certainly, the most frequently encountered etiologic factor is the pressure from the herniating mass which arises posterior to the floor of the inguinal canal and is subsequently diverted through the femoral ring. In the normal descent of the testis it is not possible to have a congenital crural saccular herniation, as there is no vestigial peritoneal remnant traversing this ring from which such a hernia can arise. Therefore, such a herniation can only occur by reason of the ductility of the peritoneum overlying the femoral ring becoming evaginated through it. The close anatomic relationship of the inguinofemoral area has been elucidated by Morgan and Anson who have described the entrance to the inguinal canal as a funnel with two spouts; one the internal ring, the other the femoral ring. Our observations (2) of the transitional area of the trihedral space are in agreement with this view. Moreover, we are thoroughly convinced that the surgical approach for the repair of a femoral hernia should invariably be through the inguina.

CONCLUSIONS

The anatomic rings and pouches of the inguinoscrotal region have been discussed in the order of their anatomic and embryonic evolution.

The parietal source-layer of the boundaries of the rings follows a standard pattern, paralleling closely the origin of the fascias of the spermatic cord.

The anatomic boundaries of each ring have been defined.

The function, vulnerability, and common errors in the clinical interpretation of the rings have been elaborated upon.

The reasons for divergence of opinion as regards the contractility or inertness of the rings have been discussed. The alleged differences when carefully evaluated in respect to their developmental or distortional variations are not as great as we have been led to believe.

It is proposed that the nomenclature of the rings of the inguinoscrotal region follow their principle boundary layer, and that they may be designated as the: (1) fascia transversalis ring, (2) transversus abdominis ring, (3) obliquus internus ring, (4) obliquus externus ring, (5) conjoined inguinoscrotal fascial ring, and (6) femoral ring.

Since an ectopic testis may occasionally be encountered during the course of a hernia repair, the surgeon should be aware of the location of the anatomic pouches in which the testis may be found. Moreover, knowledge of the diverse pathways of the testis is important in its reduction and should be a prerequisite for those doing reparative hernial surgery.

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THE SELECTION OF INFANTS AND CHILDREN FOR THE SURGICAL TREATMENT OF HIRSCHSPRUNG'S DISEASE

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DURING THE PAST 7 YEARS we have had the opportunity to study 34 patients operated on for Hirschsprung's disease in various Seattle hospitals, and another 32 referred with a questionable Hirschsprung's disease whom we have decided against operating upon. Sometimes this decision as to diagnosis has been extremely difficult and, in fact, we have reversed our opinion in several cases after a period of observation. From the material studied certain conclusions have been reached as to the proper selection of cases for surgery. Ten of the 31 operations have been performed at hospitals other than the Children's Orthopedic, and the details of the pathology involved will not be used in this discussion.

Before proceeding, we should like to offer a tentative definition of Hirschsprung's disease as we understand it. In 1886 Hirschsprung described 2 cases of constipation and obstipation in infants in which there was a narrow segment in the lower sigmoid and rectum with dilatation above. Since that time it has been pointed out that the abnormality seems to lie in the distal, rather narrow part of the colon and may be of varying length.

PATHOLOGY

The pathologic picture has been gradually elucidated, starting with Tittel in 1901 and proceeding with the help of others to Kernohan (3, 8) in 1938 and 1948, Zuelzer and Wilson, and various others since then.

A remarkably careful study with a thorough review of the previous work, including a study of 78 control cases, was presented in 1948 by Whitehouse and Kernohan of the Mayo Clinic. In this report they reviewed the prior literature and made a very detailed study of 10 cases of Hirschsprung's disease confirmed by autopsy. In each, they found that ganglion cells were missing from the myenteric plexus of various lengths of the distal colon. In addition, nonmyelinated nerve fibers were present in these aganglionic areas. The same findings have been observed in several large series including that of Swenson (4) who in the fall of 1955 published a report of his results in 150 patients.

As a rule the segment of pathologic, or aganglionic, bowel can be fairly well correlated with the narrow segment of the colon as seen by x-ray examination. The present concept of this disorder based on the work of Swenson (6) and of Hiatt is that this distal bowel without ganglion cells is without normal peristalsis and hence offers a physiologic obstruction to the fecal stream.

In our own experience as well as in most of that reported, the pathology in Hirschsprung's disease has occurred in the distal portion of the bowel for varying distances, and not in the so-called "skip" areas in the colon. Figure 1 shows the extent of involvement in a group of our cases in which the distance of the aganglionic segment was studied. Reports of isolated areas of lack of ganglion cells in other than the distal portion have been made, but these are extremely rare compared to the total number of reports.

DIAGNOSIS

History. To make a diagnosis in a severely constipated patient, the history has been of

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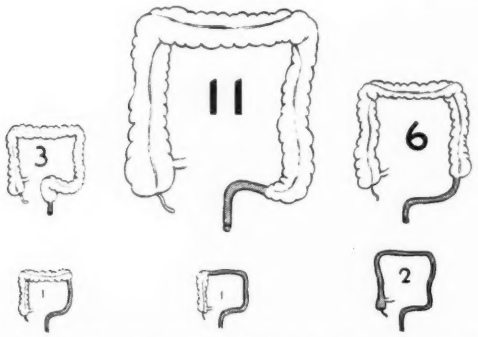

FIG. 1. Diagram of the pathology found in 24 cases of Hirschsprung's disease. The narrow stippled areas represent the extent of bowel in which nonmyelinated nerve fibers were found in the position of the myenteric plexus within each group of cases. The extent of the pathologic bowel varied from the rectum alone in 3 cases to the entire colon in 2 cases. In the largest group (11 cases) there was involvement of the rectum and the sigmoid. In none of our cases have so-called "skip" areas of this pathologic entity been observed.

the utmost importance. Among the 31 children operated on and found to have Hirschsprung's disease, *all* were proved to have been constipated since birth or within the first 2 or 3 weeks thereafter.

Many infants who do not have Hirschsprung's disease are constipated in the neonatal period. Such babies not infrequently can be cared for successfully with medical management, anal dilatation, or both. The presence of constipation in the newborn period, therefore, is not enough per se to indicate a diagnosis of Hirschsprung's disease, but in our opinion that diagnosis cannot be made in its absence. Among older children, if the onset of constipation did not occur before the age of 2 or 3 years, the diagnosis of Hirschsprung's disease is definitely ruled out, and the child is treated for functional constipation.

X-ray examination. The next helpful diagnostic aid is the x-ray examination of the lower colon. In most of our cases the roentgenogram has shown a narrow area in the distal colon, preceded by a proximal dilatation, varying in length and in what we have come to consider a typical case (Fig. 2). We have, however, been misled by the x-ray examination. A false positive diagnosis has been made on the basis of a typical x-ray film and history. False negative films have also been observed in a patient who later proved to have Hirschsprung's disease. The false negative films are liable to occur in young infants in whom the differential dilatation of the bowel has not yet had time to develop, as well as in a few older children in whom an impaction has widened the distal narrow area of the colon.

Biopsy. In the past we believed that a very necessary diagnostic test in some cases would be a biopsy of the muscle wall of the lower bowel. A rather cumbersome procedure was followed in 2 cases, namely, that of opening the abdomen for biopsy of the muscle wall of the lower sigmoid just above the level of the pelvic peritoneum. This procedure verified the diagnosis in each case, and at the same time a colostomy was performed to aid in the surgical management of the patient. Shortly after these attempts, while going over this problem with Dr. Orvar Swenson who pioneered the surgical treatment of this disease, we found that in answer to a similar problem he (5) had developed an approach through the perineum to obtain a piece of the circular muscle of the rectum for biopsy purposes.

The method used since then is as follows (Fig. 3): In preparation for biopsy the patient's lower bowel is cleansed by means of enemas, and then a sulfonamide or antibiotic is given for 4 days. At surgery the patient is placed in lithotomy position under anesthesia and the anus is dilated. A zephiran-soaked sponge is inserted in the rectum, and the perineum and anal region are given surgical preparation. The pectinate line is then grasped with an instrument and brought downward, and an incision is made just lateral and parallel to it. With small instruments, a pie-shaped piece of the circular and longitudinal muscle of the rectum is excised without perforating the mucosa. The defect is closed with 2 or 3 No. 4-0 chromic catgut sutures in the muscle and subcutaneous tissue. The patient is not uncomfortable post-

FIG. 2.

FIG. 2. Roentgenogram of colon showing what are said to be the typical features in Hirschsprung's disease. There is narrowing of the distal, pathologic bowel with enlargement of the bowel proximal to it. The dividing line in this case is at the splenic flexure.

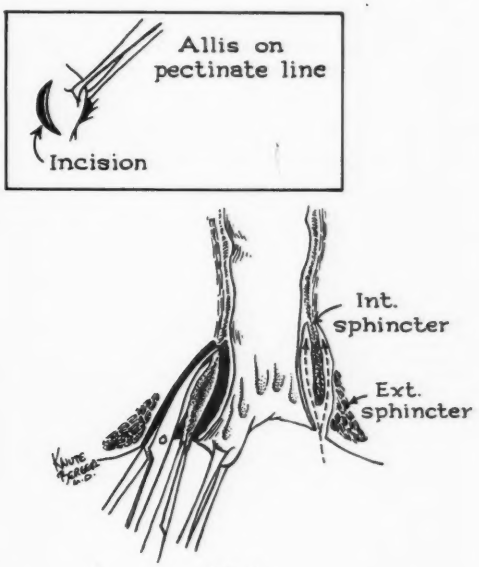

FIG .3.

FIG. 3. Drawing showing the method of obtaining a biopsy of the circular and longitudinal muscle of the rectum to determine the presence or absence of ganglion cells in the myenteric plexus.

operatively and may be up and around immediately.

We have done 12 biopsies since using this technique. In 5 instances no ganglion cells were present and the diagnosis of Hirschsprung's disease was confirmed. In 7 instances ganglion cells were present. We do not know whether it is significant that in 2 of the latter cases a reduced number was noted.

The following 2 cases will serve to illustrate the usefulness of this diagnostic measure.

CASE 1. W. C., an 11 month old baby, was first seen by experienced pediatric and surgical consultants at the age of 2 weeks with partial intestinal obstruction, vomiting, and constipation. X-ray films of the colon did not show definite evidence of Hirschsprung's disease at that time. During the following 10 months he continued to be extremely constipated in spite of good medical management, and he again returned to the hospital. A new x-ray examination was then thought to be suggestive of Hirschsprung's disease. A rectal biopsy was performed that showed no ganglion cells (Fig. 4). A week later, after thorough preparation, a Swenson pull-through operation was carried out after which the child recovered very nicely, having a stool on the third postoperative day. Figure 5 shows a photograph of the inverted specimen, and Figure 6 shows a photomicrograph of a section taken from the rectum. The latter demonstrates the lack of ganglion cells and the presence of nonmyelinated nerve fibers.

The following case illustrates an instance in which a biopsy proved helpful in deciding against a diagnosis of Hirschsprung's disease.

CASE 2. L. O., a 6½ year old girl, was referred from eastern Washington with a history of constipation known to have existed since she was 18 months of age. She was an adopted child, taken at 18 months by her childless uncle and aunt from her own home after the true parents were sentenced to jail. Her bowel history before adoption is unknown. X-ray films were not typical of Hirschsprung's disease, showing a dilated rectum; but vigorous treatment with cathartics for several weeks had been unsuccessful. With these conflicting findings, a rectal muscle biopsy was done that

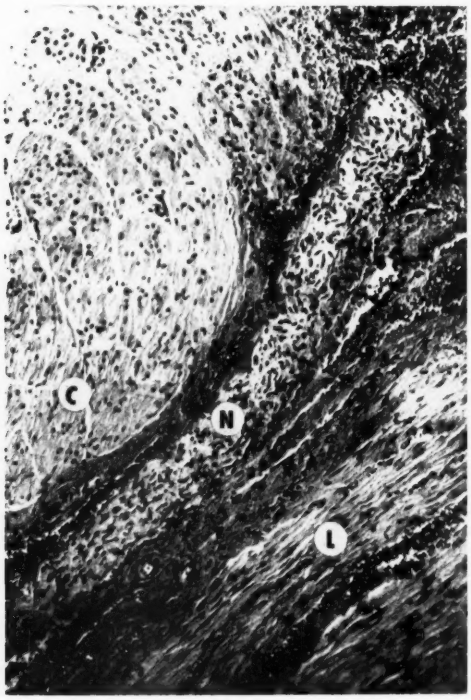

FIG. 4. Biopsy of rectal muscle in Case 1. The bundle of tissue marked *N* is composed of nonmyelinated nerve fibers, without ganglion cells in a position where the myenteric plexus is normally seen. *C* and *L* represent sections of circular and longitudinal muscles of rectum.

showed ganglion cells (Fig. 7). This observation led us to believe that the child was constipated on a psychologic basis and surgery was not performed. Medical management and reassurance of the adoptive parents have resulted in the child's developing normal bowel habits which have continued for a period of 1 year.

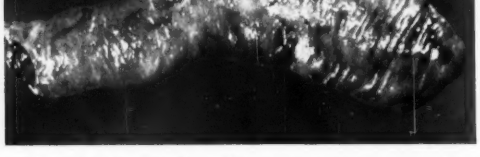

FIG. 5. Photograph of bowel specimen removed in Case 1. The specimen is inverted, with the mucosa on the outside. The narrow end on the left is rectum.

FIG. 6. Photomicrograph of section taken through the muscular layers of wall of the rectum in Case 1. *N* marks the nonmyelinated nerves without ganglion cells between the circular and the longitudinal muscle bundles (*C* and *L*).

Although the majority of our patients have shown the usual pathologic pattern, we have operated on 2 patients who fulfilled the clinical criteria for surgery, including a history of constipation since birth unrelieved by medical measures together with compatible x-ray films of the colon. Both of these patients were relieved of obstruction following surgery, and yet in each, ganglion cells were noted in the removed bowel. These children were operated on before we used the technique of biopsy of the rectal muscle. They are described to illustrate the confusion which has previously beset us in some cases.

CASE 3. T. T., an infant, was seen in the first week of life at Providence Hospital in Seattle. He was constipated to the point of obstruction and had intermittent distention and vomiting. This condition could be controlled with difficulty by the use of a rectal tube

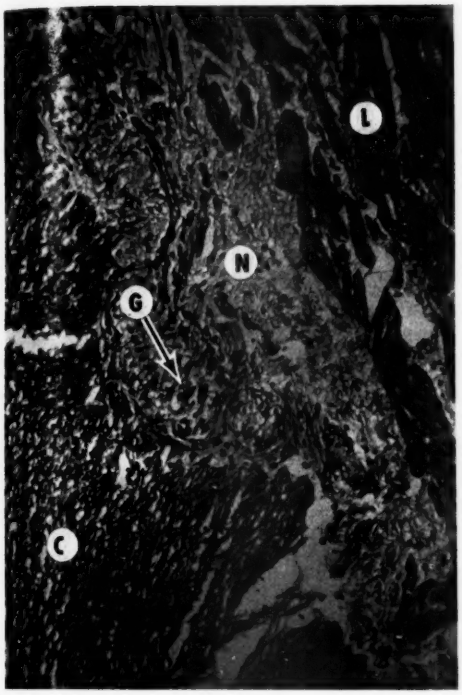

FIG. 7.

FIG. 7. Photomicrograph of normal rectal muscle section in Case 2. Ganglion cells (*G*) and myelinated nerves have a normal appearance in the myenteric plexus (*N*) which lies between the circular and longitudinal muscle bundles (*C* and *L*).

FIG. 8.

FIG. 8. Roentgenogram of colon of a 10 day old baby (Case 3) with a clinical history of partial intestinal obstruction. This film was interpreted as being compatible with Hirschsprung's disease. When the distal bowel was excised, microscopic examination of its muscular wall showed the myenteric plexus to be normal throughout the entire length of the specimen.

and enemas. A barium enema was done after his transfer to charity care at the Children's Orthopedic Hospital at 1 week of age, and the roentgenogram was interpreted as being typical of Hirschsprung's disease (Fig. 8). A transverse colostomy was performed at 10 days of age on a more or less emergency basis. Following colostomy his progress was good. At the age of 1 year the lower bowel was excised, and a pull-through operation was performed which has continued to relieve his obstruction. On pathologic examination the excised lower bowel showed ganglion cells in all areas.

CASE 4. L. R., a 2½ year old girl, was seen with a history of constipation to the point of intestinal obstruction since birth. By means of enemas given every 3 or 4 days the family had managed effectively to keep the child cleaned out. Cathartics in large doses prescribed under excellent pediatric supervision over a 5 month period, were totally ineffective. A barium enema demonstrated a narrowed distal segment compatible with Hirschsprung's disease. Because the situation could not be managed medically and because the x-ray evidence and history indicated the diagnosis, a colostomy was performed when she was 2 years and 10 months old. The need for enemas was relieved, and the child's health improved immediately. Subsequently a successful Swenson pull-through operation was performed, and the child now has 1 bowel movement a day, 2 years following surgery. In this case also, ganglion cells were observed throughout the surgically removed distal colon and rectum.

These 2 cases are presented to show that the operations were performed for distinct clinical indications, namely, those of bowel obstruction unrelieved by other means plus compatible x-ray evidence. In each case the treatment has been successful. Nevertheless, neither fulfilled the pathologic criteria of Hirschsprung's disease. We do not know whether further medical management would have been successful if a rectal biopsy had disproved the diagnosis of Hirschsprung's disease before surgery, but we hope so. Wider experience will show whether infants, such as in Case 3, will need surgery in spite of a

negative biopsy or whether they can be managed medically.

SUMMARY

A study was made of the cases of 34 children operated on for Hirschsprung's disease as well as of 32 seen because of a possible diagnosis of Hirschsprung's disease but not operated upon.

To distinguish between the patients with true Hirschsprung's disease and those with some other cause for constipation, it was found that a *history of constipation from birth* was always present in the patients with Hirschsprung's disease, and the lack of such a history seemed to rule out this condition.

X-ray examination was helpful in showing a narrowed distal segment of colon with ballooning proximal to it in most of the cases seen. However, there were both false positive and false negative x-ray findings, so that this test was not entirely reliable.

As a third diagnostic aid the technique of biopsy of the lower rectal muscle through a perineal incision was used in our last 12 cases to determine the presence or absence of ganglion cells in the myenteric plexus.

Lastly, 2 cases were observed in which the indications for surgery were definitely present on the basis of clinical and x-ray findings alone and colostomy followed by pull-through operation was successful in relieving obstruction. However, ganglion cells were observed in the excised bowel in both cases.

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THE DIAGNOSIS OF FETAL SEX DURING PREGNANCY

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A GREAT NUMBER OF TESTS have been described for the purpose of diagnosing the sex of the fetus in utero. In a survey on the subject, Blakely deals with the methods classifying them as those using the "supernatural" and those using "natural" phenomena. The latter group includes not only suggestions as to the significance in variations in the position of the fetus, its outlines, attitudes, and activities, but also the more scientific attempts at diagnosis based upon the effects of a male fetus on the total maternal organism. The saliva test and hormonal tests are examples of this approach.

All these tests have proved to be unreliable, and it was not until the descriptions by Barr, Bertram, and Lindsay; Emery and McMillan; Graham; Hunter, Lennox, and Pearson; Marberger, Boccabella, and Nelson; Moore and associates of a morphologic difference according to sex in the nuclear pattern of intermitotic cells, in humans as well as in some other mammals, that a new approach to the subject could be sought. We have previously shown that a reliable diagnosis of sex can be made before birth by a study of the chromocenters in cells of the amniotic fluid (27, 28, 30), and since our original report other works have appeared by Dewhurst, Fuchs and Riis, James, Makowski and associates, and Shettles so that the reliability of the method is now well established.

The theoretic basis of the test is founded upon the difference in the sex chromosome constitution of normal males and females—males having the XY and females the XX sex chromosome constitution (25, 26)—and the ability to identify this difference morphologically by a study of the chromocenters in human tissues and, for our purpose especially, in the embryonic tissues and cells found in amniotic fluid.

We have made a detailed analysis of a series of cases (28) showing the reliability of this method using amniotic fluid obtained at or just prior to delivery and, furthermore, using fluid obtained in the earlier months of pregnancy. It is our purpose in the present article to discuss the method of obtaining the fluid, its practicability, and the results obtained.

Materials and methods. The rupture of membranes for the purpose of inducing labor just prior to term, for various reasons, and the frequent occurrence of bulging membranes during labor provided most of the material for the examination of amniotic fluid in the ninth month of pregnancy. In such cases, a fine needle with stylet (20 gauge) was carefully inserted into the amniotic sac to avoid complete rupture of the sac. The stylet was then withdrawn only after the needle had entered the amniotic cavity, previous trial experiments having shown contamination with maternal vaginal cells with consequent distortion of the preparation when this precaution was not taken. Cesarean section gives adequate exposure of the uterine wall to allow the insertion of a lumbar puncture needle and stylet, but care is taken to do so only in cases in which the membranes have not yet ruptured, and a place on the uterine wall is chosen where the resilience indicates that there is no fetal part in direct contact with the wall. Fifty patients in the ninth month of pregnancy were examined, the fluid in 49 cases having been obtained by the methods just described and in 1 case of hydramnios,

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by abdominal paracentesis performed for therapeutic reasons.

Early months. Thirteen patients in the earlier months of pregnancy were examined. In the earliest case, an abortion at 2 months, the whole sac was expelled. Fluid (2 mls.) was obtained by withdrawal with a syringe, and preparations for confirmation were made from the fetal tissues themselves. A case in the third month of pregnancy was obtained when a hysterectomy (Professor B. Zondek) performed on a patient in her fifth pregnancy suffering from Gaucher's disease and severe anemia provided the uterus whole with the possibility of puncturing the uterus at the time of operation. Fetal tissues were again prepared as in the previous case for confirmation. Eleven cases of abdominal paracentesis were performed on pregnant women between the fourth and the seventh month of pregnancy.

Abdominal paracentesis. With the patient supine and the table in the Trendelenburg position, after catheterization the abdominal wall is prepared with a suitable antiseptic solution. The procedure can be performed after infiltration of the chosen area with a 1 per cent solution of procaine or under a general anesthetic. The site of introduction of the needle varies with the month of pregnancy and the position of the placenta, as far as this can be ascertained with soft tissue roentgenography. By careful palpation the site providing the required resilience for a safe paracentesis is located. The site of the puncture is usually somewhere between the umbilicus and the symphysis pubis, in the midline if possible, though this can be varied slightly to either side according to the case.

The needle we used was a spinal No. 19 gauge, and it is unnecessary to use any wider bore needle for the present purpose, although much wider needles have been used for other purposes. On introduction of the needle, after piercing the abdominal wall, the needle can be felt to enter the uterine musculature, and the stylet is then withdrawn. If fluid does not appear immediately in the needle, it can be manipulated a little without introducing it more deeply, when fluid will usually be seen to be rising in the needle. The amount of fluid required is about 5 milliliters although less may suffice. After the needle has been extracted, pressure is applied to the puncture site on the abdominal wall for a few minutes. The theoretic dangers which are entailed in this method of procedure will be discussed subsequently in this article.

Preparation of the slides. The fluid obtained was centrifuged at 2,500 revolutions per minute for 5 minutes. It was found that the best preparations resulted from centrifuging immediately, although 5 cases in the ninth month which were left to stand for periods of up to 10 hours before being received also gave satisfactory results. The sediment containing the cells was smeared on slides coated with Mayer's albumin and then fixed for between 1 and 24 hours in equal parts of absolute alcohol and ether. A modified Kahle's fixative and 3 to 1 alcohol-acetic acid were also tried, and although both were satisfactory they were not superior to alcohol-ether which was therefore used routinely. Slides which had to be kept for any length of time or were to be transported were rinsed in 70 per cent alcohol, 50 per cent alcohol, distilled water, and then rinsed in glycerine water.

Feulgen staining with fast green as a counterstain for the cytoplasm was used routinely for the study of chromocenters. For this stain, the slides after rinsing in water were transferred for 8 minutes to normal hydrochloric acid at 60 degrees centigrade, stained with leucobasic fuchsin for 1 hour followed by 3 rinses, totalling 10 minutes in sulfurous acid, and 3 rinses in distilled water. The slides were then rinsed in 70 per cent alcohol, 95 per cent alcohol, counterstained in a dilute fast green solution in 95 per cent alcohol, followed by 2 rinses in 95 per cent alcohol, and a rinse in absolute alcohol, equal parts of absolute alcohol and xylol, xylol, and mounted in Canada balsam.

RESULTS

Of the 63 patients examined in all, 50 were in the ninth month of pregnancy and 13 in the early months. Photomicrographs of some of the cells are shown in Figure 1. In all 50 cases in the ninth month the results were correct, there being 23 males and 27 females.

Of the 13 cases in which amniotic fluid was obtained in the earlier months correct diagnoses were made in all except 1—a pathologic pregnancy in which insufficient cells were found. In the 12 cases which were correctly diagnosed, there were 7 males and 5 females.

One case of a complete abortion at 8 weeks was diagnosed as male from the cells found in 2 milliliters of fluid, and this diagnosis was confirmed by a study of the embryonic membranes and tissues. Of the 12 cases in which fluid was obtained by abdominal puncture in the early months, 11 were diagnosable. One of these was a pregnancy in which the prognosis for a successful termination was fairly hopeless, and the test was performed in the sixth month when it seemed that abortion was inevitable. The patient had been bleeding for 2 months and passing meconium-stained fluid for 1 month, and a diagnosis of a male fetus was made. Two weeks later, after continued vaginal bleeding, she aborted a fresh stillborn male fetus. The case in which insufficient readable cells were found in order to arrive at a diagnosis was of a patient who had been bleeding for 3 days in the fourth month of pregnancy. Aspiration of 5 milliliters of brown amniotic fluid failed to provide sufficient cells of the nonpyknotic type required for studying the chromocenters. The patient has since been delivered of a normal male child.

The other 9 pregnancies tested were all normal ones, and all were diagnosed correctly. Apart from the case in which hysterectomy was performed in the third month, these pregnancies have reached successful terminations all with the birth of healthy babies.

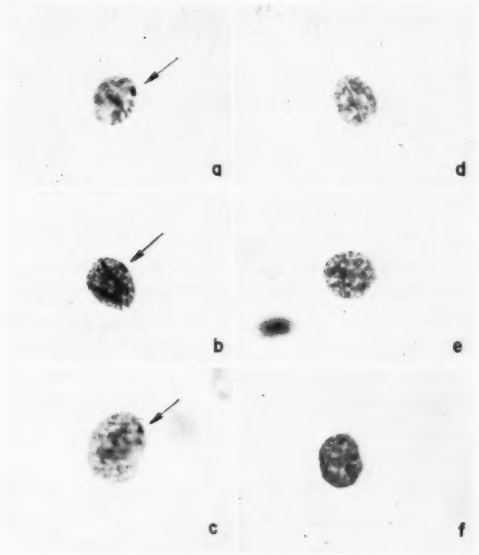

FIG. 1. Photomicrographs of cells from the amniotic fluid. Feulgen staining, ×1110. a, Nucleus with a chromocenter from a sixth month female fetus. b and c, Nuclei with a chromocenter from ninth month female fetuses. d, e, f, Nuclei without a chromocenter from ninth month male fetuses.

DISCUSSION

From the foregoing results, it may be concluded that from 16 weeks of pregnancy (or even a little earlier), by careful abdominal puncture, a reliable method of prenatal sex diagnosis is now available. Although amniotic fluid can be obtained by this method even at 12 weeks and a diagnosis be possible, it is clinically more practicable between the fourteenth and sixteenth week of pregnancy. In 1 of our cases, a patient in the fourth month of pregnancy, the puncture was easily and successfully performed, but, owing presumably to the pathology of the pregnancy at the time, the fluid was brown and contained too high a proportion of degenerated cells to allow a diagnosis to be made. On the other hand, in a patient in the third month, normal as far as the pregnancy was concerned, whose fluid was obtained from the uterus before it was extirpated, a correct diagnosis was made from 2 milliliters of fluid containing few cells. Al-

though the usual amount of fluid tested was about 5 milliliters, it should be noted that the paucity of cells in the early months does not necessitate that a larger amount of fluid be taken because in a normal pregnancy the proportion of readable (nonpyknotic) cells may be greater than in fluid from the later months. Performing the puncture in the later months of pregnancy seems to be both undesirable and unnecessary because the relatively smaller amounts of amniotic fluid and the relatively larger fetus, as compared with the ratio between the two in the earlier months, make the procedure more difficult. Results in the later months of pregnancy anyway can be of little practical value.

With regard to the theoretic dangers involved in this procedure, it should be noted that in the earlier months of pregnancy (referring to the end of the fourth to the beginning of the seventh) there is a comparatively large amount of amniotic fluid surrounding a small mobile fetus. We have found that visualization of the placental position by the use of soft tissue roentgenography, practiced so successfully in the later months by Whitehead and others, can be done too in many early pregnancies, thus giving an idea of the relative position of fetus and placenta. We decided to perform the test by this method after the successful performance of abdominal punctures for the purpose of tocodynamometry had been reported in series of over 600 cases by Alvarez and Caldeyro. Our cases, too, showed no by-effects whatsoever.

The procedure of abdominal paracentesis of the pregnant uterus is by no means a new one and has been used for various purposes. The technique has been developed and precautions described. It should be noted too that far wider bore needles have been used than we found necessary for our present purpose, when the procedure was used for recording the contractility of the uterus, and yet the authors of this work state that no ill effects were observed, no abortions, premature labors, or hemorrhages. Mueller, in a review of the literature concerning treatment in hydramnics, outlines the history of amniotic fluid aspiration through the abdominal wall. Recommended first by Schatz in 1882, the first case was reported by Henkel in 1919, and soon afterward by Wormser, the method then having been applied later and more extensively by Rivett. Those with experience of the method admit theoretic dangers but contend that there has never been a serious accident. In discussing the possible dangers it has been stated by Kellor that if the liquor is blood-stained, it suggests that a fetal blood vessel has been pierced, but that "this does not appear to be serious." Munro Kerr and Chasser Moir believe that injury to an underlying placenta is only possible in the event that the trocar is very blunt.

The procedure has been used not only for the aspiration of amniotic fluid but also for injecting substances into the amniotic cavity. The method of amniography was reported to be successful and complicated only by the toxicity of the contrast media injected. Amniography has even been said by Albano and Gallina, Cetroni and Azzariti, Granjon, and Kerr and Mackay, to enable the diagnosis in some cases of the fetal sex, so that the use of paracentesis is not revolutionary for this purpose either. Recent reviews, in connection with its use for sex diagnosis by nuclear sexing, agree that amniotic fluid can be obtained by this method if reasonable care is exercised.

On the accuracy of the test, it has been questioned whether diagnosis is at all possible in cases of dissimilar twins in one amniotic sac. As we have pointed out in our previous observations (28) analyzing the types of cells found in the amniotic fluid, in the rare instances of such types of twinning, the suspicion of its existence may be raised by finding aggregations of cells with a male picture in one and a female picture in another. The incidence of hermaphroditism would appear to be too small to make an appreciable reduction in the percentage accuracy of the test.

In spite of the accuracy of this method for the prenatal diagnosis of sex, the relative lack of danger, and the fact that it can be carried out early in pregnancy, we would not at the moment propose its use as a procedure for the mother-to-be who is simply curious.

The possible application of the test for fetal sex on clinical grounds, however, seems to us to be feasible, without the danger that many other well known medical methods are known to carry. There are known instances of sex-linked diseases in man, the symptoms of such diseases appearing in only one of the sexes, or the disease being transferred by one of the sexes. Abdominal puncture of the pregnant uterus with reasonable caution could be usefully applied in such selected cases in which the diagnosis of the sex of the embryo would enable the antenatal detection of the hereditary disorder.

Furthermore, the recent publications by Coombs and Edwards on blood grouping from epithelial cells, and its possible application to the fetus in utero, suggest other possibilities for the use of amniotic fluid in the antenatal detection of hereditary disorders, not only those that are sex-linked but also those that are caused by autosomal genes. It may be that with further advances in these fields there will be an added importance to the practicability of aspirating amniotic fluid during pregnancy.

SUMMARY AND CONCLUSIONS

The sex of 63 pregnancies (50 in the ninth month and 13 between the second and the seventh months) was tested and 62 diagnosed. One case, a threatened abortion, did not provide a sufficient number of readable cells for the diagnosis to be made.

Of the 13 cases in the earlier months of pregnancy, the fluid was obtained in 11 by abdominal paracentesis of the pregnant uterus, in 1 by puncture of the uterus at laparotomy, and in 1 from the amniotic sac of a complete abortion.

The method of obtaining the fluid by abdominal paracentesis and the preparation of the slides is described. The safety of the procedure involved is discussed.

It is concluded that from the end of the fourth to the beginning of the seventh month of pregnancy a relatively safe and reliable method of diagnosing the sex of the fetus in utero is available.

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THE USE OF TRACHEOTOMY IN THE BURNED PATIENT

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BETWEEN 1950 AND 1956, approximately 1,000 hospitalized burned patients have been treated at Brooke Army Hospital. Experiences with 64 of these patients on whom a tracheotomy was performed form the basis for this report. The chief motives for the operation in the burned patient are to prevent or treat respiratory embarrassment from either mechanical or secretional causes and to facilitate the administration of anesthesia in patients who have deep facial burns (2, 3).

These 64 patients represent some of the more seriously burned patients evacuated to this center. There were 80 deaths in the 1,000 burned patients, and, of these deaths, 37 occurred in this group of 64 patients. The percentage of body surface burned for those who expired averaged 60 per cent. The great majority of deaths were related to the extent of thermal trauma and to complications such as septicemia. In a few instances death resulted from complications involving the respiratory tract. In 2 such patients errors in tracheotomy management were partially responsible for death.

INDICATIONS

In earlier years tracheotomy was undertaken mainly to treat established respiratory obstruction. As more experience was gained, the operation became used chiefly as a prophylactic measure, especially in patients with deep facial burns. Of the 64 patients, only 8 had respiratory embarrassment at the time of tracheotomy. Although many patients presented more than one indication for performing tracheotomy, the basic or underlying reasons for the operation were of three types: to prevent or treat mechanical airway obstruction, to avoid asphyxia from retained secretions, and to facilitate the administration of anesthesia. More specifically, the clinical indications for performing the procedure consisted of the following: respiratory embarrassment, prophylaxis of secretional obstruction, respiratory tract irritation, an aid to anesthesia, a prophylactic measure in facial burns, and associated injuries.

Respiratory embarrassment (*8 patients*). These patients had respiratory distress due either to mechanical or secretional obstruction of the airway. Five patients had mechanical obstruction. In almost every instance respiratory embarrassment followed a severe external burn of the neck in which there was edema of the pharyngeal mucosa and epiglottis as well as the soft tissues of the neck. One patient, not receiving tracheotomy as part initial therapy, developed severe edema of the pharynx and required emergency tracheotomy. Three patients underwent tracheotomy because of thick, heavy secretions that caused respiratory embarrassment. Usually this occurred in patients whose normal coughing process was diminished because of their weakened condition.

Prophylaxis of secretional obstruction (*9 patients*). Tracheotomy was performed in these patients to remove retained secretions and to effect good tracheobronchial toilet. There was no respiratory obstruction at the time of tracheotomy, but because normal coughing was obtunded, it was anticipated that secretional obstruction might develop. Some of these patients were unwilling to cough because of discomfort, while others, because of age, extent of injury, or debility, were un-

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able to clear their respiratory passages spontaneously.

Respiratory tract irritation (10 patients). Ten patients had tracheotomy because damage to the air passages, as evidenced by signs of respiratory irritation, was suspected. Such patients are in danger of asphyxia both from swelling of the air passages and from accumulated secretions. This group included some of the more seriously burned patients and there was only 1 survivor. Another patient might have lived had tracheotomy been performed earlier.

An actual burn of the lower air passages probably is rare. If extensive injury to the alveoli occurs, it is unlikely that the patient will survive in spite of presently known methods of therapy. Irritation of the larger air passages is more common, especially if the individual is in a closed space when burned. Inhalation of smoke and other noxious gases causes damage to the respiratory epithelium which results in edema and increased secretions. Respiratory tract damage is suspected when there is singeing of the nasal hairs, redness of the pharyngeal mucosa, hoarseness, rales in the chest, or a history of the burning accident occurring in a closed space. The danger of asphyxia in these patients, some with serious respiratory problems, is minimized greatly if early tracheotomy is performed and efficient tracheobronchial toilet maintained.

Aid to anesthesia in face burns (19 patients). Tracheotomy was employed to facilitate anesthesia in 19 patients who had full thickness burns of the face. The tracheotomy opening provided a safe, simple, and accessible route for endotracheal anesthesia. Some patients underwent anesthesia in this manner as many as 15 times. This particular use for tracheotomy offers several advantages in the management of a patient with burns of the face (3). (1) The surgical field is free from anesthetic equipment. (2) The danger of increasing damage to the burned surface from pressure or irritation is avoided. There is a distinct hazard that if an anesthesia mask is applied over face grafts or a recently healed partial thickness burn it may cause conversion to deeper injury. (3) Intubation is simpler via the tracheotomy opening. Usually it can be accomplished after topical anesthesia of the trachea, thus avoiding the use of deep anesthesia or muscle relaxants for intubation. It is usually difficult to insert an endotracheal tube through the mouth because of contracture. Intubation through the nose is troublesome and may damage the nasal passages. (4) Difficulties from aspiration following anesthesia are lessened greatly. The patient with burns of the face and mouth is less able to cope with vomitus than the normal person.

Prophylactic measure in facial burns (17 patients). Because of the frequency with which patients having deep facial burns require tracheotomy, the procedure has been used prophylactically in 17 such patients during the past 3 years. Tracheotomy usually is carried out within the first 12 to 24 hours following injury. Early tracheotomy largely eliminates the fear of respiratory difficulty from mechanical or secretional obstruction, provides a good means for tracheobronchial toilet, and facilitates the administration of anesthesia in certain of these patients who must undergo repeated reconstructive procedures.

Associated injury (1 patient). In 1 instance tracheotomy was performed because of an associated crush injury of the chest.

DISCUSSION OF INDICATIONS

The foregoing categories outline the primary indications used at the time tracheotomy was performed. As more experience was obtained, it appeared that there were two chief types of burn involvement for which tracheotomy was employed: (1) deep burns of the face and neck and (2) respiratory tract damage from inhalation of irritating gases. Sixty of the 64 patients had facial burns and 10 had involvement of the air passages. Only 3 patients had tracheotomy performed in the absence of one of these two types of injury. If early tracheotomy is performed upon the recognition that one of these two types of burn injury is present, then the other indi-

cations seldom will arise as the initial clinical reason for performing the procedure.

TECHNIQUE OF TRACHEOTOMY

When burned patients are seen soon after injury and early tracheotomy is performed, an emergency operation is seldom necessary. If an emergency arises, the "feel" technique of Jackson probably is the safest and swiftest method yet devised for opening the airway.

Several features of the technique of elective tracheotomy are emphasized since they seem to be of practical advantage in performing the operation, protecting the airway, and facilitating after-care. When there is a deep burn of the face and neck, technically it is much easier to perform a tracheotomy before massive swelling occurs. Early, elective tracheotomy is carried out with better technique and more accurate placing of the cannula if performed before it becomes urgently necessary. The optimum level for the tracheotomy opening is at the third to fifth tracheal ring. If the thyroid isthmus overlies this area, it is preferable to divide the isthmus rather than to retract it or place the tracheotomy opening in a less favorable location. If the tracheotomy tube is dislodged, then the retracted isthmus may return to its former position over the tracheal opening and cause difficulty in replacement of the tube as well as blockage of the artificial airway.

The most important feature in technique is the excision of a segment of one of the tracheal cartilages. Such an opening permits easier insertion of the tracheotomy tube; it prevents the edges of the trachea from approximating in case the tube slips out; and it provides a patent opening for easier entry of the endotracheal tube during anesthesia. Occasionally, it may be necessary to perform bronchoscopy through the tracheotomy opening. This procedure is much easier if a segment of anterior tracheal wall has been excised. The excision technique causes no complications or delay in healing of the tracheotomy wound.

AFTER-CARE AND COMPLICATIONS

There are three basic steps in proper after-care of a tracheotomy: (1) humidify the inspired air, (2) aspirate tracheobronchial secretions carefully and efficiently, and (3) observe, clean, and change the cannula as often as necessary. Most of the serious complications that occurred were concerned with mistakes in postoperative management, rather than with errors occurring at the time of tracheotomy. Bleeding from a tracheotomy wound occurred in 2 patients after they recovered from shock; but it was not serious in either case. Unilateral pneumothorax occurred in 1 patient who was dyspneic at the time of tracheotomy. The condition was recognized and treated successfully by water-seal drainage.

Blockage of the cannula and tracheobronchial tree resulted from crusting of secretions in 3 patients. It was the cause of 2 serious episodes of respiratory distress in 1 patient. Humidification of inspired air plus liquefaction of the secretions usually prevents the occurrence of crusting. If crusting is not prevented by these measures or relieved by proper aspiration, then bronchoscopy should be performed. Bronchoscopy through the tracheotomy opening is a more simple technique than by the usual oral route, especially if a segment of anterior tracheal wall has been excised.

In 2 patients the airway was jeopardized temporarily during intubation through the tracheotomy opening when the anesthesiologist had difficulty in inserting the endotracheal tube through a slit in the trachea. No such difficulties were encountered in patients when the excision technique was used.

Errors in tracheotomy management contributed materially to the death of 2 patients. In the first patient, a 2 year old child, tracheotomy was performed early because of respiratory tract irritation. The tracheotomy tube was too long and caused an erosion of the carina and posterior wall of the trachea. The resulting infection and tracheal obstruction was a contributing factor in the death of this child.

The other patient was a young man having 13 per cent of the body surface burned. Tracheotomy was performed because of injury to the respiratory passages from the inhalation of noxious fumes. Unfortunately, the tracheotomy tube was too short to allow for swelling of the neck. During the act of swallowing, the patient dislodged the cannula from the trachea into the soft parts of the neck and death from asphyxia occurred before the airway could be restored. At postmortem examination, it was found that only the tip of the cannula had been within the tracheal lumen. Respiration through normal channels was impossible because of edema about the glottis, which was closed tightly.

SUMMARY AND CONCLUSIONS

Of 1,000 hospitalized burned patients treated at Brooke Army Hospital between 1950 and 1956, in 64 tracheotomy was performed as part of the treatment. Tracheotomy was used to prevent or correct mechanical airway obstruction, to avoid respiratory distress from accumulated secretions, and to facilitate the administration of anesthesia. Clinically, the operation was performed in the presence of respiratory embarrassment, to prevent secretional obstruction, for respiratory tract irritation, to aid in anesthesia, as a prophylactic measure in deep facial burns, and for associated injury. In nearly every instance the need for tracheotomy was occasioned by the presence of deep face and neck burns or respiratory tract involvement. If early tracheotomy is performed upon the recognition of either of these two types of burn involvement, then the other indications seldom arise as the initial clinical reason for using the procedure.

The incidence of avoidable complications associated with tracheotomy is sufficient to warrant careful attention to every aspect of technique and after-care. Particular attention should be given to the size and fit of the cannula, to humidification of inspired air, and to proper aspiration of tracheobronchial secretions. One important step in increasing the ease of all aspects of after-care is the use of the technique of tracheotomy in which a portion of the anterior tracheal wall is excised. This technique provides a safer airway in case the tracheotomy tube is dislodged, or if it needs to be replaced with another cannula, a bronchoscope, or an endotracheal tube.

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EXPERIENCE WITH THE MANCHESTER OPERATION

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DURING THE PAST 20 YEARS at the University of California Hospital, San Francisco, the Manchester operation has been the mainstay of the gynecologist's surgical armamentarium in the treatment of genital prolapse. In the course of this time, a considerable experience has been accumulated at this institution in the performance and the vagaries of this procedure. There has been, however, a recent tendency to revert to the older operation of vaginal hysterectomy with anterior and posterior repair (Fig. 1) in the management of the various degrees of uterine prolapse associated with herniations of the bladder and rectum. It would seem appropriate at this time, therefore, to pause and reflect and to evaluate this experience and the results which have been achieved with an operation which was not only one of the first consistently successful procedures in the treatment of genital prolapse but stands today, with little change, the most effective treatment for the majority of cases.

The history of the development of the surgical technique which is called the Manchester operation is well known and perhaps best described in the recent literature by William Fletcher Shaw (5, 6) of Manchester University, who was House Surgeon under the originator of the operation, Archibald Donald. It was in 1888 that Donald began to combine the previously performed operations of anterior colporrhaphy, posterior colporrhaphy, and cervical amputation with a shortening of the bases of the broad ligaments by suturing them with buried catgut sutures. His technique later was modified by Fothergill (2, 3), who widely publicized the procedure and introduced it to the gynecologic world. The operation has been altered further in minor details from time to time, but the basic principles remain the same, to resuspend the uterus by shortening and reapplying the cardinal ligaments to the anterior surface of the amputated cervix, to correct the existing cystocele by a reapplication in the midline of the stretched and torn pubovesicocervical fascia, and to eliminate any rectocele by performing the same maneuver with the fascia which separates the vagina and rectum and approximating the levator ani muscles in the midline. A perineorrhaphy is done, and it is customary to combine these procedures with a plication of the periurethral tissue in the presence of a urethrocele and a reduction of the contents, high ligation of the sac, and approximation of uterosacral ligaments if an enterocele is also found.

The technique of the Manchester operation has been well described on numerous occasions in the medical literature and will not be repeated here. However, various gynecologic surgeons differ in the details of the surgical technique, and it would seem germane to enumerate the sequence of the different steps in the operation as performed and taught at the University of California Hospital:

1. Large or redundant labia minora are sutured back to the vulvar skin on either side.
2. A preliminary dilatation and curettage is performed.
3. An inverted T incision is made in the anterior vaginal wall, lateral flaps are developed, and the pubovesicocervical fascia is dissected free of the vaginal mucosa.
4. The cross section of the T incision is then continued in a circular fashion about the cervix, and the vaginal mucosa is separated from the cervix and the cervical attachments of the bases of the broad ligaments.
5. These cardinal ligaments are then separated from their cervical attachments and ligated.

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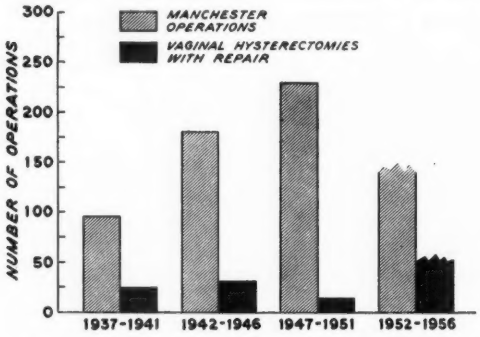

FIG. 1. Comparison of Manchester operation with vaginal hysterectomy for uterine prolapse.

6. An amputation of the cervix is carried out after ligation of the descending cervical branch of the uterine artery on either side.

7. The posterior cervical lip is covered with vaginal mucosa by use of the Sturmdorf technique.

8. The cardinal ligaments are now brought anterior to the amputated cervix and secured.

9. A reapproximation of the fascia between the bladder and vagina is done, and a Kelly type urethral plication is carried out at this time if necessary.

10. The excess vaginal mucosa is trimmed, and the anterior vaginal wall reconstructed.

11. A recovering of the anterior cervical lip with vaginal mucosa completes the anterior portion of the repair.

12. A V-shaped incision is made in the skin of the perineal body, the posterior vaginal wall is dissected free of the underlying rectum, and the excess is excised in a Christmas-tree fashion. This is carried out almost to the posterior vaginal fornix if an enterocele repair is to be done.

13. The perirectal fascia is approximated in the midline and sutures are placed to bring together the pubococcygeal portions of the levator ani muscles.

14. The vaginal mucosa is closed, the levator sutures are tied, and a perineorrhaphy completes the posterior repair.

15. A gauze wick is placed in the cervical canal, the vagina is packed, and an indwelling catheter is placed in the urinary bladder.

MATERIAL

The present study consists of 505 Manchester operations performed at the University of California Hospital during the 15 year period from 1937 through 1951. For the purpose of providing a homogeneous group for study and comparison, only those cases in which cervical amputation was performed in addition to plication of the cardinal ligaments and colporrhaphy are included. These operations were performed largely by members of the teaching and resident staffs at this hospital. One hundred and thirty-three operations were performed on private patients and 372 on staff patients. Each case report was analyzed for the following information: age and parity of the patient, presenting complaints, predominant pelvic findings prompting the choice of the Manchester procedure, immediate and late complications attributable to the procedure, lesions other than prolapse involving the uterus at the time of surgery, disease developing in the uterus subsequent to the operation, pregnancies following the Manchester operation, and, finally, the results which were achieved by the method.

AGE AND PARITY

The youngest patient in the series was 24 years of age. Seventy-nine years was the age of the oldest, and the average age was 51 years. As indicated in Figure 2, showing the number of patients in the various age groups by decades, 101 (20 per cent) of the operations were performed on patients under 40 years of age or within the childbearing range. Two hundred and eighty-seven patients (56.8 per cent) were 50 years of age or over, considered the postmenopausal group.

There were 14 nulligravid patients representing cases of pelvic floor relaxation of congenital origin. Of the remaining 491 patients, 67 had delivered 1 viable infant, while at the opposite extreme, 1 patient was a para 14. Two hundred and twenty-eight patients had delivered either 2 or 3 children. The remaining patients had more than 3 children. The average parity was 3.4.

PRESENTING COMPLAINTS

By far the most common symptom which prompted the patient to seek medical care was that of a vaginal protrusion. This was the presenting complaint in 262 (51.8 per cent) patients. One hundred and thirteen (22.3 per cent) had symptoms varying from a dragging sensation in the pelvis to a sense of "something falling down" or of pressure in the lower abdomen, back, or pelvis. These were classified under the category of pelvic insecurity. Stress incontinence was the primary symptom in 71 (14.1 per cent) patients although it occurred as a secondary manifestation 27 times. The remaining presenting symptoms in the order of decreasing frequency were as follows: abdominal pain 12 cases, low back pain 11 cases, urinary frequency 8 cases, asymptomatic 7 cases, postmenopausal bleeding 4 cases, constipation (requiring digital pressure) 3 cases, menorrhagia 3 cases, urinary incontinence 2 cases, dyspareunia 2 cases, irregular menses 2 cases, vaginal bleeding 2 cases, dysmenorrhea 1 case, missed menstrual period 1 case, and vaginal discharge 1 case.

PREDOMINANT PELVIC FINDING

Although prolapse of the uterus is almost always associated with some degree of anterior and posterior vaginal wall relaxation, it was found that in 320 (63.4 per cent) patients, the herniation of the bladder or rectum overshadowed the uterine descensus as a finding on pelvic examination, and in the majority of patients complaining of vaginal protrusion, the offending structure was more often the bulging bladder or rectum than the prolapsed uterus. Descensus was the prominent finding in 181 (35.8 per cent) cases, however, and the various degrees of prolapse are tabulated in Table I. For the purpose of definition, at this institution a first degree prolapse is one in which the cervix descends to the level of the ischial spines; a second degree prolapse indicates descent to the perineum; it is classified as third degree when the cervix protrudes through the introitus; and fourth degree represents complete prolapse or the condition in which the entire uterus has descended beyond the introitus. No distinction was made for the normally supported corpus with a cervix which descends because of elongation and hypertrophy although this was the case in several instances.

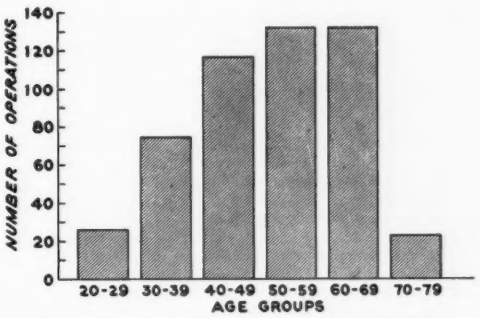

FIG. 2. Number of patients in various age groups.

It is of interest that when the descensus was considered the primary lesion, 60 per cent involved a protrusion beyond the hymenal ring of a portion of the uterus or the entire structure. Ten per cent of the Manchester operations were performed on uteri which had undergone complete prolapse.

When uterine prolapse did not exist as a predominant finding, it was noted as a secondary manifestation in 170 patients. Thus, although the operation was designed originally for the treatment of descensus of the uterus, it was used for this purpose in 351 (69.5 per cent) of the cases reported. The indications at this hospital for the Manchester operation have been broadened to include those patients without a significant degree of prolapse but with cystocele or rectocele and cervical lacerations with chronic cervicitis.

The preoperative diagnosis of enterocele was made in but 2 patients of the entire group. This defect was recognized and repaired at the time of surgery in 8 patients and recurred subsequently in 2 of these. In 6 patients, the existence of an enterocele was not recognized at the time of surgery but developed "de novo" subsequently, in some patients within a few months of the operation. In all likelihood these existed as small defects and were missed at the time of the original operation.

TABLE I.—PHYSICAL FINDINGS IN 505 PATIENTS

	Primary No. of cases	*Secondary No. of cases*
Cystourethrorectocele	320	94
Uterine descensus	181	170
First degree	3	48
Second degree	67	116
Third degree	59	5
Complete	52	1
Chronic cervicitis	3	11
Broken down hysterotomy scar	1	
Enterocele		2
Third degree laceration of perineum		1

COMPLICATIONS

The immediate postoperative complications were divided into 3 groups: urinary tract infections, surgical complications, and medical complications, all of which are listed in Table II. The 96 patients with urinary tract infections, predominantly cystitis, represent the largest group. This complication undoubtedly occurs with great frequency due to the routine use of an indwelling urethral catheter with gravity drainage for several days following surgery and the need for frequent catheterizations for residual urine in the postoperative period. Most of these infections were readily controlled with sulfonamides or appropriate antibiotics. Our study does not include an analysis of the offending organisms.

TABLE II.—IMMEDIATE POSTOPERATIVE COMPLICATIONS

	No. of cases	*Total*
Urinary tract infections		96
Cystitis	89	
Pyelonephritis	7	
Surgical complications		23
Postoperative hemorrhage	7	
Postoperative shock	2	
Perineal hematoma	2	
Infected pelvic hematoma	2	
Parametritis	2	
Rectovaginal fistula	1	
Unilateral ureteral block	1	
Bilateral ureteral block	1	
Tubo-ovarian abscess	1	
Bladder neck constriction	1	
Fractured clavicle (fall from bed postop. injury)	1	
Acute thrombosed hemorrhoids	1	
Separation of suture line	1	
Medical complications		30
Febrile course, etiology undetermined	6	
Thrombophlebitis	5	
Pulmonary embolus	4	
Atelectasis	3	
Bronchopneumonia	2	
Homologous serum jaundice	2	
Unrecognized pregnancy	1	
Transfusion reaction	1	
Parotitis	1	
"Toxic" jaundice	1	
Postoperative psychosis	1	
Grand mal epilepsy	1	
Myocardial infarction	1	
Cerebrovascular accident	1	

Postoperative hemorrhage was the next most frequent troublesome situation in the postoperative period and occurred in 7 patients, 2 of whom developed shock due to blood loss. These hemorrhages occurred, for the most part, several days postoperatively and were treated primarily by packing the vagina for hemostasis and replacing blood loss. In only 1 case was it necessary to return the patient to surgery to suture the bleeding point. Bleeding into the tissues of significant magnitude developed in 4 patients following surgery. Two of these patients had perineal hematomas while the others had infected pelvic hematomas.

Despite the precaution of separating the fascial attachments between the bladder and cervix and elevating the bladder prior to suturing the bases of the broad ligaments, the ureters were involved in 2 patients—one a unilateral block, while the other developed complete anuria postoperatively due to ligation of both ureters. This was treated by performing bilateral nephrostomies and taking down the anterior repair. It was believed that this accident was due to an abnormally low insertion of the ureters into the bladder, and the blockage was released by freeing the sutures placed to plicate the internal vesical sphincter. Both ureters subsequently resumed normal function, although intravenous urograms 2 years later revealed slight residual ureterectasis.

The fact that the majority of these patients were parous women past the childbearing age—many with varicose veins—predisposed them to the development of thrombophlebitis. Furthermore, the prolonged lithotomy position, with the attendant flexion of the hip and knee joints producing some degree of venous stasis, accentuated this tendency.

Thrombophlebitis was diagnosed postoperatively in 5 patients. There were 3 patients in whom pulmonary emboli occurred, none were diagnosed as having thrombophlebitis before the embolic episodes. One patient had 2 separate embolic episodes and survived following anticoagulant therapy. Another, a 40 year old woman, succumbed rapidly following a massive pulmonary infarction on the sixteenth postoperative day. The only other operative death in this series occurred as a result of myocardial infarction on the second day following surgery in a 64 year old woman who was recognized preoperatively to be a relatively poor surgical risk by reason of coronary artery disease.

Late complications directly related to the operation, shown in Table III, were seen in 17 patients. Five of these involved cervical strictures which required dilatation, and in 2 cases pyometra developed as a result of the stenosis.

The mortality rate for the group was 0.4 per cent; the morbidity rate, 32.7 per cent.

TABLE III.—DELAYED POSTOPERATIVE COMPLICATIONS

	No. of cases
Cervical stenosis	5
With pyometra 2	
Fistula in ano	2
Inclusion cyst of perineum	2
Stenosis of vaginal introitus requiring secondary repair	2
Rectovaginal fistula	1
Anal stricture	1
Painful perineal scar	1
Perineal sinuses (chronic granulomas due to nonabsorbable suture)	1
Transient coccygodynia	1
Breakdown of trachelorrhaphy	1
Total	17

COINCIDENT DISEASE OF THE UTERUS

Among the patients studied, there were 18 with significant disease involving the uterus at the time of surgery (Table IV). Twelve of these were benign and 6 involved malignant processes.

Among the benign group, there were 4 patients with fibromyomas, 3 of whom were treated by combining the operation with subtotal hysterectomy. The fourth patient, whose planned abdominal operation was deferred because of excessive blood loss during the vaginal repair, subsequently refused the recommended surgery.

In 3 cases, endometrial hyperplasia was found in the curettings. No further treatment was given, and in no case were sequelae recorded in subsequent examinations.

Of 3 patients who presented with menorrhagia due to dysfunctional uterine bleeding, 2 were treated with postoperative roentgen castration and 1 with intracavitary radium. One of the patients treated with roentgen rays complained of persistent intermittent,

TABLE IV.—DISEASE INVOLVING UTERUS AT TIME OF SURGERY

Case No.	*Disease*	*Treatment*	*Follow-up*
1	Squamous cell carcinoma of cervix, "early"	Diagnosis by biopsy preoperatively; serial sections of amputated cervix negative. No further treatment	5 yrs.—negative
2	Postmenopausal bleeding, etiology undetermined	Intracavitary radon insertion	18 yrs.—negative
3	Menorrhagia, primary	X-ray castration postoperatively	1 yr.—negative
4	Fibromyomata uteri	None	None
5	Squamous cell carcinoma of cervix, L of N I	Radium, 4,000 mgm. hours	4 yrs.—negative
6	Fibromyomas uteri	Subtotal hysterectomy	1 mo.—negative
7	Third degree retroversion	Defundectomy and suspension	3 yrs.—negative
8	Squamous cell carcinoma of cervix, L of N I	None	13 yrs.—negative
9	Fibromyomata uteri	Subtotal hysterectomy	1½ yrs.—negative
10	Endometrial hyperplasia	No further therapy	1 mo.—negative
11	Fibromyomata uteri	Subtotal hysterectomy	6 yrs.—negative
12	Endometrial hyperplasia	No further therapy	7 yrs.—negative
13	Squamous cell carcinoma of cervix, L of N I	2,000 mgm. hours radium	9 yrs.—negative
14	Menorrhagia, primary	Intracavitary radium, 1,500 mgm. hours	3 yrs.—negative
15	Adenocarcinoma of the endometrium	Total hysterectomy and bilateral salpingo-oophorectomy 6 weeks postoperatively	7½ yrs.—negative
16	Squamous cell carcinoma of cervix, L of N I	Radium—3,000 mgm. hours	7 yrs.—negative
17	Endometrial hyperplasia	No further therapy	1 yr.—negative
18	Menorrhagia, primary	X-ray castration postoperatively	3 yrs.—irregular bleeding episodes

L of N I, League of Nations Stage I.

irregular vaginal bleeding 3 years later. One patient with postmenopausal bleeding, the cause of which was not determined at the time of curettage, was treated with intracavitary radon at the time of the Manchester operation. There was no recurrence in an 18 year follow-up.

A defundectomy with ventrofixation of a markedly retroverted uterus was carried out in 1 case.

Of the malignant lesions, there were 5 cases in which a diagnosis of early squamous cell carcinoma of the cervix was made. Four of these were not suspected clinically and were discovered on microscopic examination of the amputated cervix. Of these patients, 3 were treated with postoperative radium applications, and all were alive and well from 4 to 9 years later. The fourth patient received no subsequent therapy and 13 years later demonstrated no recurrence. The diagnosis in the fifth case was established by preoperative biopsy, but inasmuch as careful study of the amputated cervix revealed no residual carcinoma, no postoperative treatment was prescribed. There was no evidence of recurrence in a 5 year follow-up examination.

These cases demonstrate that, in the presence of benign lesions involving the uterus, the Manchester operation can be combined with appropriate additional therapeutic measures directed at the eradication of these lesions. For the most part, the diagnosis of malignant disease was made in retrospect. This was primarily because the malignancy in each instance was in an early stage of development and was asymptomatic. Had the presence of a carcinoma been recognized preoperatively, it is unlikely that the procedure would have been performed. The fact that these lesions were incipient, however, allowed a cure in each case through relatively simple measures.

SUBSEQUENT DISEASE OF THE UTERUS

Twenty-five patients (5.0 per cent) developed subsequent disease involving the uterus of sufficient degree to require additional therapeutic measures and these are listed in Table V. The shortest duration from the time of the Manchester operation until the onset of symptoms was 6 months, and the longest interval recorded was 6 years, the average being 3.3 years.

The therapy given these 25 patients involved 22 dilatations and curettages, 8 hysterectomies, 1 x-ray castration, and 3 intracavitary radium applications.

Of significance are the facts that no patient developed subsequent carcinoma in the remaining portion of the cervix but 2 patients developed adenocarcinoma of the endometrium. One of these patients was treated by radiation and surgery, while the other was treated by surgery alone.

The 5.0 per cent incidence of significant subsequent disease involving the uterus raises the question of the advisability of preserving the uterus unless there is a wish to retain the childbearing function. The proponents of the Manchester operation believe that the uterus is essential to an adequate anatomic reconstruction of the pelvic floor. They cite the high incidence of prolapse of the vaginal vault following vaginal hysterectomy and the difficulties encountered in the management of this condition. In this series the incidence of malignant disease involving the uterus following the Manchester operation was only 0.4 per cent. This, in itself, is not considered sufficiently significant to warrant the practice of prophylactic vaginal hysterectomy.

PREGNANCIES AFTER MANCHESTER OPERATION

Sterilization procedures were carried out in 21 of the 101 patients under 40 years of age upon whom the Manchester procedure was done. Pregnancy developed subsequently within 6 months in 1 of these patients due to failure of a Pomeroy ligation. Fourteen of the remaining 80 patients were known to have conceived following the operation, and 1 patient was operated upon in the early second trimester of pregnancy, the preoperative diagnosis of pregnancy having been missed. She was delivered of a viable infant by elective cesarean section 4 months following the Manchester procedure.

TABLE V.—SUBSEQUENT DISEASE INVOLVING THE UTERUS

Case No.	Disease	Interval	Therapy	Follow-up
1	Postmenopausal bleeding	3 yrs.	Radium application	2 yrs.—negative
2	Menorrhagia	4 yrs.	Dilatation and curettage	
		5 yrs.	Dilatation and curettage	
		6 yrs.	X-ray castration	None
3	Menorrhagia	9 mos.	Dilatation and curettage	
		17 mos.	Dilatation and curettage	
		21 mos.	Subtotal hysterectomy	1 mo.—negative
4	Postmenopausal bleeding (endometrial polyp)	1 yr.	Dilatation and curettage, intracavitary radium	1 mo.—negative
5	Adenoacanthoma	3 yrs.	Radium plus total hysterectomy and BSO	2 yrs.—negative
6	Menorrhagia (incomplete shedding)	6 mos.	Dilatation and curettage	1 yr.—negative
7	Menorrhagia	3 yrs.	Dilatation and curettage	7 yrs.—negative
8	Atypical hyperplasia	6 yrs.	Dilatation and curettage	2 mos.—negative
9	Postmenopausal bleeding	6 yrs.	Dilatation and curettage	4 mos.—negative
10	Postmenopausal bleeding	?	Dilatation and curettage, 2 times	None
11	Endometriosis	5 yrs.	Total hysterectomy and BSO	6 yrs.—negative
12	Menometrorrhagia		Dilatation and curettage, 2 times	4 yrs.—negative
13	Postmenopausal bleeding (endometrial hyperplasia)		Dilatation and curettage	None
14	Menometrorrhagia (endometrial hyperplasia)	3 yrs.	Dilatation and curettage	4 mos.
15	Menometrorrhagia	3 yrs.	Dilatation and curettage	1 yr.—negative
16	Menometrorrhagia	5 yrs.	Dilatation and curettage	None
17	Fibromyomata uteri, adenomyosis	3 yrs.	Hysterectomy	3 mos.—negative
18	Menorrhagia		Dilatation and curettage	3 yrs.—negative
19	Postmenopausal bleeding	1 yr.	Dilatation and curettage	3 mos.—negative
20	Menorrhagia (atypical hyperplasia)		Dilatation and curettage, 2 times	1 yr.—negative
21	Adenocarcinoma of endometrium	6 yrs.	Total hysterectomy and BSO	8 mos.—negative
22	Postmenopausal bleeding		Rx. refused	None
23	Fibromyomata uteri	2 yrs.	Total hysterectomy and BSO	4 yrs.—negative
24	Menometrorrhagia		Vaginal hysterectomy	1 yr.—negative
25	Endometrial hyperplasia and polyps, 2 times	2 yrs.	Dilatation and curettage	
		4 yrs.	Total hysterectomy	1 yr.—negative

BSO, bilateral salpingo-oophorectomy.

In the 14 known patients who became pregnant following the operation, conception occurred within 1 year in 8. The other patients all bore children within 4 years, and 2 delivered 2 infants within this period.

Seventeen pregnancies, then, were known to have occurred in 15 patients following the Manchester operation. In this group there was 1 spontaneous abortion at 20 weeks' gestation, and another patient was lost to follow-up when she moved to another city. Of the remaining 15 deliveries, 10 were vaginal in 8 patients and 5 by elective cesarean section. In those who delivered from below, there were no prolonged labors, but there was 1 nineteen hour labor due to uterine inertia with delivery of an anencephalic monster. Eight spontaneous and 2 low forceps deliveries were recorded. One baby was premature and the rest were over 2,500 grams. The largest infant weighed 4,070 grams and was delivered by outlet forceps after a 5 hour labor.

Two patients were lost to follow-up after delivery, 1 after cesarean section, and the other after a vaginal delivery, but the remainder were followed from 6 months to 8 years. In 7 patients followed after vaginal delivery, 6 patients had subsequent demonstrable pelvic floor relaxations of varying degree, 4 of whom were symptomatic, and 2 had vaginal repairs at a later date. The 4 patients delivered by elective cesarean section who were followed were seen from 1 to 5 years postpartum. All remained asymptomatic, and there were none who demonstrated a recurrence of any manifestation of genital prolapse, the anatomic result being rated as satisfactory in each case.

It would seem apparent that, although this represents a very small number of pregnancies observed following the Manchester procedure, there is no evidence to indicate that the operation, as defined to include amputation of the cervix in each instance, materially affects the course of subsequent

TABLE VI.—OVER-ALL RESULTS OF MANCHESTER OPERATION

	No.	*Per cent*
Patients followed	456	90.3
Anatomical results		
Satisfactory	346	75.9
Unsatisfactory	110	24.1
Subjective results		
Cured	392	86.0
Improved	33	7.2
Failed	31	6.8

pregnancies. Vaginal delivery of a viable infant following the operation, however, leads to a relatively high incidence of recurrences of pelvic floor relaxation. This can be prevented by performing elective cesarean section.

RESULTS

Follow-up examinations were recorded on 456 patients, representing 90.3 per cent of the total cases. The results were evaluated both from the standpoint of the anatomic outcome, as well as the effectiveness of the operation in relieving the patient of her symptoms. From the objective position, a result was considered unsatisfactory if there was any element of pelvic relaxation. In order for an anatomic result to be rated as satisfactory there had to be no evidence of recurrence of uterine prolapse, cystourethrocele, rectocele, or enterocele, no matter how slight. If the patient, over the duration of the follow-up period, was not relieved of her symptoms, or if new symptoms developed which could be related to pelvic relaxation, she was not considered cured. The operation was adjudged to be a failure if it did not relieve the presenting complaint or if there were other symptoms which developed during the follow-up period which were of equal or greater severity than the original complaints. If the symptoms were only partially relieved, the subjective result was classified as "improved."

TABLE VII.—RESULTS IN RELATION TO LENGTH OF FOLLOW-UP

Length of follow-up	*Satisfactory*	*Unsatisfactory*	*Cure rate, per cent*
	ANATOMICAL RESULTS		
1–6 mos.	138	20	87.3
6–12 mos.	59	16	78.7
1–3 yrs.	66	30	68.7
3–10 yrs.	74	40	64.9
Over 10 yrs.	9	4	69.2

Length of follow-up	*Cured*	*Improved or failed*	*Cure rate, per cent*
	SUBJECTIVE RESULTS		
1–6 mos.	149	9	94.3
6–12 mos.	67	8	89.3
1–3 yrs.	77	19	80.2
3–10 yrs.	91	23	79.8
Over 10 yrs.	8	5	61.5

Length of follow-up	*Satisfactory*	*Unsatisfactory*	*Cure rate, per cent*
	ANATOMIC RESULTS		
Less than 1 year	197	36	84.5
More than 1 year	149	74	66.8

Length of follow-up	*Cured*	*Improved or failed*	*Cure rate, per cent*
	SUBJECTIVE RESULTS		
Less than 1 year	216	17	92.7
More than 1 year	176	47	78.9

TABLE VIII.—RESULTS IN RELATION TO AGE OF PATIENT

	40 years and over		*Less than 40 years*	
	No.	*Per cent*	*No.*	*Per cent*
Patients followed	366		90	
Anatomical				
Satisfactory	272	74.3	74	82.2
Unsatisfactory	94	25.7	16	17.8
Subjective				
Cured	317	86.6	75	83.3
Improved	30	8.2	3	3.3
Failed	19	5.2	12	13.3

Using these criteria, the over-all results are tabulated in Table VI. This shows that the operation was anatomically satisfactory in 75.9 per cent of the patients followed, whereas 86.0 per cent demonstrated complete relief of symptoms. The 110 unsatisfactory anatomic results include 6 cases, and the 31 subjective failures include 4 cases which were rated as such after vaginal deliveries following the Manchester procedure. If the figures are corrected for these, the results are 77.0 per cent satisfactory anatomic results and 86.7 per cent subjective cures.

It was discovered in analyzing the results, however, that the favorable outcome diminished in frequency with continued observation for over 1 year, after which the results became more or less stable (Table VII). This led to the conclusion that the results of the operation were valid only for those patients who were followed for more than 1 year.

Because of this tendency, the cure rates were calculated separately for those patients

followed less than 1 year and for those seen in follow-up for more than 1 year after the Manchester operation. This calculation indicated an anatomic cure of 84.5 per cent in those followed less than 1 year and 66.8 per cent in those followed for more than a year. Subjectively, the figures were 92.7 per cent and 78.9 per cent respectively.

The anatomic results were better in the patients under 40 years of age than in the older age group (Table VIII). This was believed to be due to several factors. First, the various degrees of pelvic relaxation were apt to be more pronounced in those patients beyond the childbearing years. Secondly, the postmenopausal women, in general, presented tissues which were more atrophic and more friable than those of their younger sisters. Certainly the supporting structures were less well developed and provided less to work with in reconstructing the visceral supports. Thirdly, although estrogens were supplied exogenously in many, the lack of hormonal effect in the older woman probably contributed to the poorer anatomic results through reduced vascularity and delayed healing. Despite these factors, it is interesting to note that the subjective response in the two groups was comparable.

SUMMARY AND CONCLUSIONS

1. The Manchester operation, at the University of California Hospital, San Francisco, has proved to be an effective procedure in the treatment of genital prolapse.

2. Its usefulness covers a wide range with respect to age, parity, symptoms, and varying degrees of pelvic floor relaxation, including complete prolapse of the uterus.

3. The most common complication of the operation is that of urinary tract infection.

4. The mortality rate from the procedure at this institution over a 15 year period was 0.4 per cent.

5. This operation can be combined with others designed to effect appropriate therapy of coincident disease involving the uterus.

6. The incidence of unsuspected malignancy in the operative specimen was 1.0 per cent. These were very early lesions, however, and appropriate therapy effected a clinical cure in each instance.

7. Subsequent malignant disease of the uterus developed in 0.4 per cent of the patients. The operation did not prevent proper treatment of these lesions.

8. There was no subsequent development of carcinoma involving the remaining cervix in this series, indicating that the Manchester operation with cervical amputation may prevent this disease.

9. The operation does not adversely affect subsequent pregnancy. In those patients who became pregnant, the incidence of abortion was not increased. The procedure did not materially interfere with the normal processes of labor. However, vaginal delivery following a Manchester operation produced a high incidence of recurrent genital prolapse. This was prevented in the patients delivered by elective cesarean section.

10. The over-all results of the operation revealed that 86.0 per cent of the patients followed were completely relieved of their symptoms, 7.2 per cent demonstrated some improvement, and 6.8 per cent were considered failures. Anatomically, 75.9 per cent were rated as satisfactory with no evidence of any element of pelvic floor relaxation. Follow-up examination for less than 12 months produced results which were not considered valid. In those patients followed for more than 1 year, 78.9 per cent remained free of symptoms, and the anatomic cure rate was 66.8 per cent.

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THE ASSOCIATION OF THE ABO BLOOD GROUPS TO GASTRIC CARCINOMA

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INTEREST in the possible relationship of the ABO blood group to oncology is attested to by the reports of Buchanan and Higley, and Alexander in 1921, Johannsen in 1925, Goldfeder and Fershing in 1937, and Mayo and Fergeson in 1953. These and other investigators failed to demonstrate a statistically significant association between the ABO blood group and cancer in general, or gastric carcinoma in particular.

In 1950 Stocks reported a higher standardized mortality for carcinoma of the stomach in northern than in southern English towns; he suggested that the probable explanation for these findings was an unidentified environmental factor. Aird, however, thought the observed differences could just as well be related to genetic factors, possibly reflected in the known differences of the ABO blood type frequencies of these two geographic regions. In 1953, Aird, Bentall, and Fraser Roberts reported the findings of a well planned and executed study which conclusively demonstrated that in the population of Great Britain, the frequency of blood type A is significantly higher and O lower in patients with gastric carcinoma as compared with a normal population sample. Since the frequency of blood type O was higher in the northern English towns, the results of this study did not explain the geographic differences reported by Stocks; the evidence suggested both environmental and inherited factors. Similar findings have since been reported by Hollander from Switzerland (cited by Aird and associates) and Køster, Sindrup, and Seele from Denmark.

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The full implications of the observed association remain to be realized. Interested clinical and basic scientists alike have regarded this association as perhaps the frontier of a new field of investigation, development of which may lead to an understanding of fundamental considerations having to do with the cause of gastric cancer, cancers in general, and the broader aspects of heredity and disease. The immediate need is for the collection of similar data from other population groups throughout the world which will help to establish the significance of these findings and point the way for subsequent researches. This is a report of such a study conducted in the state of Iowa.

MATERIALS AND METHODS

The methods employed in collecting and evaluating the data have been described (4); clinical material was provided by the hospitals listed in Table II.

From the clinical records of the 6 different hospitals, those were selected in which (1) a histologic diagnosis of carcinoma of the stomach was noted, and (2) blood type information was present. No other factors entered into case selection, all records of patients with a diagnosis of gastric carcinoma from the different hospitals having been examined. In order to insure uniformity of the data, all records were reviewed and cases selected by members of the research team. Numerous correlation studies were made possible by transferring the data to punch cards and using machine sorting methods. In evaluating the findings, the blood type frequencies observed in the patient and a disease-free sample of the population from which the patients came were compared.

The latter were healthy blood donors seen at either of two hospital blood banks (Methodist and University) (Table I). The observed blood type frequencies or blood type percentages for this group are henceforth referred to as controls. Comparison of gene frequencies, which may be calculated as described by Dobson and Ikin, indicates the same association. The statistical significance of the differences were tested by the chi square and differences in percentages methods.

TABLE I.—BLOOD TYPE OF NORMAL BLOOD DONORS USED FOR CONTROLS

Blood type	*No.*	*Per cent*
O	2892	45.8
A	2625	41.6
B	570	9.0
AB	226	3.6
Total	6313	100.0

TABLE II.—NUMBER OF PATIENTS WITH EACH BLOOD TYPE BY HOSPITAL

	Blood type				
	O	*A*	*B*	*AB*	*Total*
University	301	313	64	15	693
Veterans*	21	32	3	—	56
Mercy, Iowa City	26	35	8	2	71
Methodist, Des Moines	24	29	8	5	66
Broadlawns, Des Moines	11	7	1	3	22
Total No.	383	416	84	25	908
Per cent	42.2	45.8	9.2	2.8	100.0
Difference in per cent from controls	−3.6	+4.2	+0.2	−0.8	0.0

*Iowa City and Des Moines Veteran's Hospital patient groups have been combined.

RESULTS

The numbers of patients with each blood type from each hospital are recorded in Table II. When the findings for the different hospitals were compared, no significant differences with regard to the observed blood type frequencies could be demonstrated. It was therefore suitable to combine the data and treat them as one homogeneous sample. At the bottom of the table are recorded the total number of patients with each blood type, the blood type percentages and differences in each instance from the blood type percentage observed in the control group.

In Table III are indicated the possible combinations which can be made in examining the data, chi square values computed when these are made and the levels of significance thereby indicated.

Let us examine the blood types O and A findings in the patient and control groups:

	O	*A*	*Totals*	*Per cent A type*
Gastric carcinoma	383	416	799	52.07
Controls	2892	2625	5517	47.58
	3275	3041	6316	

In this case, $X^2=\frac{[(383)(2625)-(416)(2892)]^2(6316)}{(3275)(3041)(5517)(799)}=5.623$

with 1 degree of freedom.

Since X^2 at the 2 per cent level of significance with 1 degree of freedom is 5.412 and at the 1 per cent level of significance with 1 degree of freedom is 6.635 we have a result which is significant at the 2 per cent level; hence, $.01<P<.02$. That is, we assert that type A is significantly higher in gastric carcinoma than in the controls.

This result is supported by considering the difference in percentages based upon the normal curve theory;

$$t=\frac{.5207-.4758}{\sqrt{\frac{(.5207)(.4793)}{799}+\frac{(.4758)(.5242)}{5517}}}=\frac{.0449}{.0189}=2.38$$

which again is significant at the same level.

Since most persons have either O or A blood type and because of the increase in A and reciprocal decrease in O in the patient group, comparison of the O and A findings with the control values as suggested by Aird, Bentall, and Fraser Roberts affords the most

TABLE III.—POSSIBLE COMPARISONS OF GASTRIC CARCINOMA PATIENTS WITH CONTROLS INDICATING CHI SQUARE VALUES AND LEVEL OF SIGNIFICANCE FOR EACH COMPARISON

Blood types compared	X^2	*Level of significance (probability)*
O A B AB	7.607	.05<P<.10
O A B	5.697	.05<P<.10
O A AB	6.968	.02<P<.05
O B AB	1.678	.10<P
A B AB	2.697	.10<P
O A	5.623	.01<P<.02
O B	.688	.10<P
O AB	.685	.10<P
A B	.321	.10<P
A AB	2.765	.05<P<.10
B AB	1.424	.10<P

TABLE IV.—PATIENTS WITH EACH BLOOD TYPE, DIFFERENCE FROM CONTROLS, CHI SQUARE VALUES, AND LEVELS OF SIGNIFICANCE FOR THE CLINICAL CHARACTERISTICS STUDIED

Blood type	*Rh factor*		*Sex*		*Family history of ca.*		*Family history of gastric ca.*		*Spread*		
	+	−	*M*	*F*	+	−	+	−	*Local*	*Nodes*	*Viscera*
O											
No.	222	32	270	92	73	310	27	310	65	73	151
Per cent	42.1	36.4	42.6	42.2	38.2	43.2	33.8	43.2	43.0	37.2	46.2
Difference	−3.7	−9.4	−3.2	−3.6	−7.6	−2.6	−12.0	−2.6	−2.8	−8.6	+0.4
A											
No.	236	48	280	104	100	316	44	316	66	97	142
Per cent	44.8	54.5	44.2	47.7	52.4	44.1	55.0	44.1	43.7	49.5	43.4
Difference	+3.2	+12.9	+2.6	+6.1	+10.8	+2.5	+13.4	+2.5	+2.1	+7.9	+1.8
B											
No.	51	7	65	16	13	71	6	71	17	21	26
Per cent	9.7	8.0	10.2	7.3	6.8	9.9	7.5	9.9	11.3	10.7	8.0
Difference	+0.7	−1.0	+1.2	−1.7	−2.2	+0.9	−1.5	+0.9	+2.3	+1.7	−1.0
AB											
No.	18	1	19	6	5	20	3	20	3	5	8
Per cent	3.4	1.1	3.0	2.8	2.6	2.8	3.7	2.8	2.0	2.6	2.4
Difference	−0.2	−2.5	−0.6	−0.8	−1.0	−0.8	+0.1	−0.8	−1.6	−1.0	−1.2
Total	527	88	634	218	191	717	80	717	151	196	327
X^2	3.642		2.115		4.845		4.685			4.984	
Level of significance	.10<P		.10<P		.10<P		.10<P			.10<P	

simple, straightforward, and perhaps, significant method of analysis. The absence of a decrease in the blood type B frequency, as noted for O and AB, explains lower level of significance for comparisons involving B.

Data concerning Rhesus blood type, sex, family history of carcinoma, family history of gastric carcinoma, and the spread of the neoplasm noted at the time of operation are recorded in Table IV. No significant degree of heterogenicity could be demonstrated between the groups of patients compared. Only the results of the over-all comparison, i.e., O and A and B and AB comparison, are recorded although other comparisons were made, with similar results. Of lesser interest were the findings with regard to age (median and mean in sixth decade), race, social and economic status, occupation, and gastric acidity which appear to have no relevance to the gastric carcinoma-ABO blood group association and are not recorded.

TABLE V.—CONTROL PATIENT BLOOD TYPE PERCENTAGES AND THE DIFFERENCE IN PER CENT

Author	*No. of patients*	*Blood type*	*Control, per cent*	*Gastric cancer, per cent*	*Diff. in per cent from control*
Aird, Bentall, Fraser Roberts	3,632	O	48.6	44.5	−4.1
		A	39.8	44.8	+5.0
		B	8.3	7.8	−0.5
		AB	3.2	2.9	−0.3
Hollander*	704	O	41.6	36.2	−5.4
		A	45.1	53.1	+8.0
		B	9.0	7.5	−1.5
		AB	4.3	3.2	−1.1
Køster, Sindrup, Seele	413	O	40.6	34.1	−6.5
		A	44.0	51.3	+7.3
		B	10.9	10.7	−0.2
		AB	4.5	3.9	−0.6
Buckwalter *et al.*	908	O	45.8	42.2	−3.6
		A	41.6	45.8	+4.2
		B	9.0	9.2	+0.2
		AB	3.6	2.8	−0.8

*Cited by Aird *et al.*

COMMENT

When one remembers the considerable differences in blood type frequencies which occur in various areas of the world or even within the United States, the difficulty in obtaining a representative sample of the population from which normal blood type frequencies can be determined is clear. Blood donors who were relatives and friends of the patients, coming from the same stock, same geographic area with similar ethnologic backgrounds, would appear to provide a relatively homogeneous and reliable control group.

The most important result of this study is the primary finding of an association similar to that previously reported between gastric cancer and the ABO blood group. As indicated by the data recorded in Table V, our findings suggest an association not quite as strong as that found by the other investigators. Size of the patient samples, varied

criteria of case selection and experimental methods, and differing degrees of homogeneity in the patient and control groups are the most obvious explanations. Whether in addition there are other more subtle factors related to the anthropologic aspects of the population groups, or other undetected genetic and environmental factors acting to select cases, remains to be determined by further investigations. The failure of the earlier investigators to find an association between gastric cancer and the ABO blood group was most probably due to unsatisfactory controls, heterogeneity of the patient group with regard to the disease being studied, or to the lack of proper methods of statistical analysis.

As data from different population groups accumulate indicating an association between the ABO blood group for this and other diseases, it becomes more probable that a causal relationship rather than merely a chance association exists. Conversely, the attractive explanation of population stratification related to local anthropologic factors becomes less tenable. Evidence currently available does not permit adequate testing of the hypothesis that the mucopolysaccharide blood group substances may act with or as carcinogens or, as seems more plausible, may act independently to protect the gastric mucosa or make it more vulnerable. The finding of a highly significant increase in blood type O among peptic ulcer patients makes such a hypothesis more attractive, whereas, the observation of associations of the ABO blood group to other disease suggests a more fundamental relation to the biochemical and physiologic make-up of the individual.

The results of the evaluation of the data concerning the clinical characteristics are of interest although no statistically significant relationships to the primary gastric carcinoma-ABO blood group association have been demonstrated. In order to evaluate these possibilities properly, more data must be collected and studied. The suggestion of a familial predisposition is supported by the observations of Macklin, State and his associates, and Vidabaek and Mosbeck.

SUMMARY

When the ABO blood type frequencies of 908 patients with gastric carcinoma were compared with those observed in a normal population sample, significant differences were noted. There was an increase of blood type A, reciprocal decreases in types O and AB, and no change in type B, in the patient group. No significant relationship of age, sex, social and economic status, Rhesus blood type, family history of carcinoma, gastric acidity, or degree of spread, to the association between the ABO blood group and gastric carcinoma could be demonstrated. At present, the explanation for these findings, their significance with regard to the cause of gastric carcinoma, and the broader concepts of the role of heredity in disease are matters for speculation and further investigation.

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THE RESULTS OF SUBTOTAL COLECTOMY AND ILEOPROCTOSTOMY IN THE TREATMENT OF CHRONIC ULCERATIVE COLITIS

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IT IS GENERALLY AGREED that the surgical treatment of chronic ulcerative colitis should consist of total colectomy and creation of a permanent ileac stoma. While a permanent ileac stoma may not be desirable, usually most patients with ulcerative colitis accept it in preference to the chronic debilitating disease that has plagued them. However, a more desirable procedure would be ablation of the diseased tissue with re-establishment of the bowel continuity, provided it would leave the patient at least as well off as would colectomy and ileostomy.

The criticisms of subtotal colectomy and ileoproctostomy are, first, the diseased rectum remains and thereby subjects the patient to all the exacerbations of an inflammatory process and, second, they expose the patient to the risk of increased susceptibility to malignant transformation in the rectum. However, there have been scattered reports in the medical literature both in the United States and abroad of gratifying results following subtotal colectomy and ileoproctostomy in selected cases. Because of these reports and a few of our own recent experiences, we decided to appraise the results we have obtained with this type of therapy.

MATERIAL

Accordingly, the case records of all patients with chronic ulcerative colitis who were treated here by subtotal colectomy and ileoproctostomy through 1953 were studied. Cases in which there were malignant lesions of the colon in addition to ulcerative colitis were excluded from the study except for 2 cases in which pathologic examination disclosed polyps that were the site of grade 1 adenocarcinoma without involvement of the stalk. A total of 30 cases was found to be suitable for evaluation. There were 14 women and 16 men. Their average age at the time of initial operation was approximately 34 years, and the range in age was from 15 to 68 years. They were found to have had the disease for an average of 6.8 years, the range being from 1 to 23 years. The indications for surgical intervention were variable, as follows: stricture of the colon, 10 cases; polyposis, 10 cases; intractable disease, 7 cases; perforation into the urinary bladder, 1 case; colonic fistulas, 2 cases; and possible malignant change in the colon, 4 cases. In 4 cases there were 2 or more of these indications for operation.

All patients underwent sigmoidoscopic examinations before operation. Eight patients had no evidence of chronic ulcerative colitis in the rectum. Of the remaining 22 patients, 2 had pseudopolyps of the rectum, 6 had anal fissures or rectal fistulas, 1 patient had a small rectal stricture only, and 13 patients had varying degrees of involvement from anal scarring to active ulcerative proctitis characterized by granular, punctate bleeding mucosa and ulcers.

One stage subtotal colectomy and ileoproctostomy were performed in 16 cases. Eleven patients underwent a two stage procedure consisting of ileoproctostomy followed later by subtotal colectomy. Three patients underwent multiple stage procedures, eventually undergoing ileoproctostomy; of these 3 patients, 1 had a prelimi-

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nary left hemicolectomy and terminal transverse colostomy, next a right hemicolectomy and ileostomy, and, later, closure of the ileac stoma and ileoproctostomy. None of the patients underwent subtotal colectomy and ileostomy followed later by closure of the ileac stoma and anastomosis of the ileum with the rectal stump. In all the patients a variable length of the terminal part of the ileum was resected in order to remove any disease that had involved the ileum; 17 of the 30 specimens thus removed showed involvement of the terminal part of the ileum with chronic ulcerative colitis.

In follow-up studies, patients who had not been seen at the clinic during 1955 were sent questionnaires. By these means, 25 patients were traced. Two patients had not been seen at the clinic since their operations and could not be traced by questionnaire. Three patients could not be traced by questionnaire but letters of inquiry to their local physicians brought the following information: 1 patient had had an "external anal fistula" and had had radium treatment for carcinoma of the cervix; the second patient had had a malfunctioning ileorectal stoma shortly after the operation that had been performed here, and had required resection and reanastomosis but was reported to be doing well; the third patient underwent proximal ileostomy but the stoma was later closed and the patient was in good health. One patient had died 6 years after operation but the cause of death was undetermined. Each of 2 patients who responded to the questionnaire stated that he had undergone permanent ileostomy elsewhere, because of a persistent enterocutaneous fistula. There remained, thereby, 22 patients whose condition could be evaluated further.

FOLLOW-UP OBSERVATIONS

Of these 22 patients, 15 had various degrees of involvement of rectum with chronic ulcerative colitis prior to operation. This involvement consisted of rectal polyps in 1 case, rectal or anal scarring in 5 cases, rectal stricture in 1 case, anal fissure or rectal fistula or both in 5 cases and granular rectal mucosa in 3 cases. Five patients who exhibited no rectal disease after operation had had, before operation, rectal stricture, anal fistula, anal scarring, rectal ulcers, and bleeding mucosa respectively. One of these 5 patients was found to have several ulcers of the rectal mucosa 1½ years after operation, but 2½ years after operation proctoscopic examination showed the rectum to be normal. One of the 15 patients who had rectal involvement had not undergone proctoscopic examination after operation. Of the remaining 9 patients who continued to exhibit disease in the rectum after operation, 3 had rectal polyps, 1 had slight stenosis at the site of anastomosis, 1 had an anal fissure and an inactive anal fistula, and 4 had active proctitis.

Seven patients had no evidence of chronic ulcerative colitis in the rectum before operation. After operation, 4 patients were not examined proctoscopically, 2 gave negative results on proctoscopic examination, and 1 had a small rectal stricture.

It seemed a significant indication of improved health that 21 of the 22 patients had gained weight after operation; the weight of the 1 patient who failed to gain remained unchanged. Of further significance, 20 patients said they were fully active and had been able to carry on full time jobs or household duties. Indeed, 3 of these patients said they were pregnant then, 2 of them having already had an uncomplicated pregnancy after operation. One patient reported that he could engage in only moderate activity, and another, a man 62 years old, who had been operated on 17 years before, said that he was able to perform only light farm work.

Twenty patients had control of the bowel while 2 had slight rectal incontinence that required the wearing of a perineal pad.

On the average, 11 patients had 1 to 5 stools, 6 patients had 5 to 8 stools, and 5 patients had more than 8 stools per 24 hours. In 8 cases the stools were usually formed (soft), in 12 they were usually loose, and in 2 they were usually watery. Eight patients occasionally had noted slight bleeding from

the rectum after operation, while the other 14 had not noted any rectal bleeding.

An attempt was made to elicit reports of any complications that had developed after operation. One patient said he had a recurrently draining enterocutaneous fistula, 4 had had rectal polyps fulgurated either at this clinic or elsewhere, 1 patient had had a rectal fistula removed, 1 had an anal fissure, 1 had undergone temporary ileostomy for intestinal obstruction but the stoma later was closed, and 2 had had obstruction of the small bowel from adhesions which required surgical intervention.

SUMMARY AND CONCLUSIONS

Of 30 patients who had undergone subtotal colectomy and ileoproctostomy for chronic ulcerative colitis at the Mayo Clinic, 25 subsequently were either examined at the clinic or traced by questionnaire and their condition evaluated. One of the 25 patients had died and 2 of the patients had had permanent ileac stomas established since operation at the clinic. There remained, thereby, 22 patients whose postoperative clinical course could be studied in detail. On the basis of the observations made on these 22 patients it was concluded that there are instances, although rare, in which abdominal colectomy with ileoproctostomy is a justifiable procedure in cases of ulcerative colitis. It is assumed, of course, that the operation is not performed in cases in which the disease has affected the rectum more than minimally.

THE USE OF SURFACE AREA AS A BASIS FOR ESTABLISHING NORMAL BLOOD VOLUME

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THE ACCURATE, scientifically sound determination of the blood volume in adult patients has been the subject of much research, speculation, and endeavor in the last 40 years. From the first rough, though ingenious, attempts to discover the exact capacity of the intravascular compartment to the present quantitative dilution techniques, this rather nebulous entity has been found to lie within an extremely broad range in the normal individual, and considerably outside that scope in disease. The obvious need for an exact, fairly infallible method of computing the normal volume quickly in a specific instance has long been appreciated.

"NORMAL" BLOOD VOLUME

In surveying the literature in the field of blood volume studies, it became apparent that there is considerable lack of agreement as to what constitutes the normal blood volume for a given individual at a given time. The reason for this is that there are many factors which enter into the definitive value which ideally should represent the normal intravascular capacity; a sum total of all of these factors is well-nigh impossible, the over-all characteristics of any individual being the sum of his general state of health, age, sex, recent weight gain or loss, and the factors of blood-rich and blood-poor tissues. As to the last, muscle and skin can, for example, be contrasted with bone and fat, the former containing a large proportion of blood to mass, the latter a relatively small proportion. This can be resolved further into two large groups, the first being the metabolically active tissue mass, and the second the over-all metabolic rate of this tissue mass; obviously, the greater the amount of this active mass, as opposed to the inactive, the greater will be the measurable circulating volume, as pointed out by Sjöstrand.

Various standards for plasma and/or total blood volume have been employed with respect to weight, or normal weight, for a given individual, or expected normal weight with obesity correction (Randall's factors), or height, or height and weight, or surface area, or any or all of the above with age and sex correction, or any of several combinations of these. Acceptable deviations from the norm in any given instance have been quoted at from 5 to 30 per cent, with regard to these previously stated factors.

In the treatment of the emergency state, it is imperative that a definite, logical value be assigned to the expected normal blood volume for a given patient without delay. In our experience, it was found that amazing discrepancies existed when the usual standards for normals were applied. This was found to be particularly true when weight alone was considered, the commonly accepted value of 80 cubic centimeters per kilogram of body weight placing deficits in massive upper gastrointestinal bleeders under study beyond reasonable limits. For that reason, it was hoped that a practical, valid standard for normal blood volume on a purely empiric basis might be found; further, that a significant group of factors contributing to

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this normal value might be selected, and the results expected to fall within a reasonable range, as, e.g., 10 per cent of the true *determinable* total volume.

The immediate importance of the normal value to work from, as far as therapeutic measures in emergency states, is obvious. A reliable guide to therapy in such conditions as massive bleeding from any source, burns, and shock is what is desired. This is in direct contrast to the comparative determinations which are carried out in the course of therapy or in the postoperative period, when a set standard is not of the utmost importance that the surgical emergency reflects. However, in the routine preoperative determinations performed upon debilitated patients undergoing extensive surgery (the so-called "chronic shock" state), the replacement of depleted vascular stores is reflected in a much improved response to the trauma of the surgical period, with a shorter convalescence and markedly decreased number of complications. Here, a knowledge of the normal or standard physiologic vascular capacity will prevent overloading a depressed cardiovascular system with limited reserve and will allow for the adequate preoperative preparation that is desired.

It should also be emphasized that the discussion thus far has dealt only with the normal or with that patient in whom a knowledge of the normal volume is desirable; certain states, notably portal hypertension, cardiac failure, pregnancy, blood dyscrasias, hyperthyroidism, high altitude residence, and arteriovenous fistulas, result in a permanent deviation from the normal blood volume, and the assessment of such a patient from the normal standpoint is not reasonable.

Because of the several systems of developing the normal value currently employed, it was decided to undertake a highly empiric study of a fairly large group of normal patients, whose random selection would tend to obviate specific trends, and to plot the calculated blood volume against the predetermined normal for comparative purposes.

METHODS

At present, by far the simplest, most rapid, and most widely applied method of determining plasma volume is the employment of I^{131} as iodinated human serum albumin. This isotope is a fairly powerful beta and gamma emitter, and, hence, may be quantitatively assayed with either an end-window Geiger-Mueller tube, or a scintillation tube of any common design. The I^{131} is easy to handle, is readily available, is completely nontoxic, and quite inexpensive. The total blood volume is customarily determined from the plasma volume by use of the venous hematocrit, just as with Evans blue; further discussion of the true, so-called "total body hematocrit" will be presented.

One hundred and fifty surgical patients were selected from the general surgical service of the Cook County Hospital in such fashion that the admission diagnosis and subsequent hospital management could have no discernible effect on their circulating volume. Most of these patients were admitted for minor surgical procedures or for trauma of a minimal nature, none had suffered appreciable blood loss, and all were preoperative. The ages ranged from 14 to 76 years, the mean being 46.8 years; of the 150 patients, 89 were females, 61 were males; the group was composed of 94 colored patients and 56 white patients; the average hospital stay prior to the blood volume determination was 2.7 days.

The determinations were performed, in their entirety, by one of us (R.J.B.), in order that all minor laboratory technique be performed with some degree of uniformity. The method used was that of tagging the plasma with radioactive iodinated human serum albumin, and the whole blood volume determined from the plasma volume by use of the venous hematocrit in the following manner after the method of Ellison and associates:

$$\text{1-Plasma volume} = \frac{\text{Net counts per c.c. standard per minute} \times 1{,}000}{\text{Net counts per c.c. per minute plasma sample}}$$

$$\text{2-Total blood volume} = \frac{\text{Plasma volume} \times 100}{100 - (\text{hematocrit} \times 0.96)}$$

The standard was made up from the stock solution of 6 to 8 microcuries of I^{131} per 20 cubic centimeters. Then, 20 cubic centimeters of this stock solution were carefully introduced into a 1 liter volumetric flask and diluted to 1 liter, following which an identical 20 cubic centimeter volume of the stock solution, sterile, was injected intravenously. At 15 minutes, 8 to 10 cubic centimeters of whole blood were drawn from an antecubital vein on the opposite side without stasis, a hematocrit tube (Wintrobe) filled, and the hematocrit tube and the remainder of the specimen centrifuged at 3,000 revolutions per minute for 30 minutes.

One cubic centimeter of plasma was pipetted off into a disposable plastic tube, and the activity in this 1 cubic centimeter counted in a well-type scintillation counter. The efficiency of the well crystal has made possible the use of extremely small doses of I^{131}, as low as 5 microcuries per determination, with no loss of accuracy, due to the extreme efficiency (38 to 42 per cent) of the counter. Three counts, 5 minutes each, were recorded for each specimen, and the average count per minute used in formula 1; the standard was counted in an identical manner. The value for the hematocrit was, as can be seen, corrected for the trapped plasma, using the factor of 0.96, and the total blood volume determined from formula 2.

A further simplification was attempted in that 1 cubic centimeter of whole blood was counted prior to the centrifugation of the specimen drawn at 15 minutes: The counts per minute of this sample were used as a basis for determining whole blood volume, the plasma volume being derived by utilization of the hematocrit. A comparison of these values with those obtained by the preceding technique is shown in Table I. It is readily seen that most determinations utilizing whole blood counts are slightly higher than those using plasma counts, probably because the more viscid whole blood adheres to the sides of the pipettes, and even adding lesser amounts of distilled water as an after-wash probably does not cause full delivery of the specified volume. Also, the amount of plasma varies with the hematocrit, and this is somewhat variable. In general, it is believed that the lesser pitfalls associated with plasma counting make for sufficiently increased accuracy to warrant the extra centrifugation.

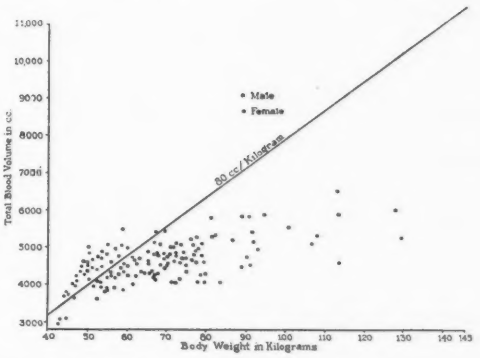

FIG. 1. Comparison of determined blood volumes and calculated "normal" volumes in 150 normal hospital patients on the basis of body weight.

RESULTS OF STUDY

Figure 1 shows the charted aggregate total blood volumes constituting the normals in this study. The straight inclined line represents the previously mentioned arbitrary figure of 80 cubic centimeters per kilogram of body weight. It is seen that the normals approach the 80 cubic centimeter value only in the lower weight ranges, perhaps to 56 kilograms; thereafter, the grouping shows that expected curvilinear dropoff indicating the presence of excess blood-poor tissue. This dropoff plotted to a rough straight line semilogarithmically, and, therefore, it was decided that the factor of surface area, incorporating both height and weight to yield a nomographic product, after Boothby and Sandiford (1), would be the more logical yardstick.

The nomographic value was employed by Gibson and Evans, in 1937, in their work with Evans blue determinations in 90 patients; in relating surface area to blood volume, they found the extreme ranges of 30 per cent above and below their curvilinear

TABLE I.—COMPARISON OF BLOOD AND PLASMA VOLUMES OBTAINED WITH PLASMA COUNTING AND WHOLE BLOOD COUNTING IN NORMAL AND HYPOVOLEMIC PATIENTS

Patient	*Whole blood counts, cubic centimeters*	*Plasma counts, cubic centimeters*	*Difference, cubic centimeters*	*Per cent difference*	*Patient*	*Whole blood counts, cubic centimeters*	*Plasma counts, cubic centimeters*	*Difference, cubic centimeters*	*Per cent difference*
1 W.S.	P1-2930 WB-5069	2984 5181	64 112	2.1 2.2	21 A.P.*	P1-3619 WB-5385	3561 5299	− 58 − 86	1.6 1.6
2 H.G.	P1-3064 WB-4047	3196 4222	132 175	4.2 4.2	22 M.O'H.*	P1-2660 WB-3993	2655 3980	− 5 − 13	0.2 0.3
3 W.S.	P1-3723 WB-6053	3658 5943	− 65 −110	1.8 1.8	23 J.S.	P1-2945 WB-5000	2846 4832	− 99 −168	3.4 3.4
4 A.P.	P1-3068 WB-4303	2840 3993	−228 −310	7.4 7.4	24 J.S.*	P1-2332 WB-4210	2608 4708	276 498	11.2 11.2
5 W.S.*	P1-3288 WB-5844	3209 5710	− 79 −134	2.4 2.3	25 H.G.*	P1-2829 WB-3876	2925 4015	96 139	3.3 3.3
6 E.G.	P1-3172 WB-4842	3006 4589	−166 −253	5.4 5.3	26 W.G.	P1-4262 WB-6438	4187 6325	− 75 −113	1.8 1.8
7 J.H.	P1-3847 WB-5811	3632 5486	−215 −325	5.7 5.7	27 W.B.	P1-3190 WB-5500	3087 5322	−103 −178	3.3 3.3
8 J.H.*	P1-3353 WB-5708	3424 5833	71 128	2.1 2.2	28 F.B.	P1-3809 WB-6851	3599 6473	−210 −378	5.7 5.7
9 G.S.*	P1-2677 WB-4062	2477 3758	−200 −304	7.7 7.7	29 F.B.*	P1-3607 WB-6476	3670 6589	63 113	1.7 1.7
10 G.S.*	P1-2912 WB-4353	2766 4135	−146 −218	5.2 5.1	30 W.G.*	P1-3940 WB-6041	3895 5974	− 45 − 67	1.2 1.1
11 J.R.	P1-2763 WB-4698	2691 4577	− 72 −121	2.6 2.6	31 B.T.*	P1-2070 WB-3981	1923 3698	−147 −283	7.4 7.4
12 J.R.*	P1-2841 WB-4634	2726 4447	−115 −187	4.1 4.1	32 J.P.*	P1-2772 WB-5007	2710 4885	− 62 −122	2.4 2.4
13 P.D.	P1-3589 WB-4691	3505 4582	− 84 −109	2.4 2.4	33 J.S.*	P1-3122 WB-5981	3047 5837	− 75 −144	2.4 2.4
14 H.C.	P1-3111 WB-5355	2965 5103	−146 −252	4.8 4.8	34 C.S.	P1-2555 WB-4252	2571 4277	16 25	0.6 0.6
15 J.W.	P1-3625 WB-6439	3522 6256	−103 −183	2.9 2.9	35 T.T.	P1-2876 WB-5045	2783 4882	− 93 −163	3.3 3.3
16 P.D.*	P1-3324 WB-5441	3036 4972	−288 −469	9.1 9.0	36 C.G.	P1-3802 WB-5931	3776 5891	− 26 − 40	0.7 0.7
17 H.C.*	P1-3335 WB-5441	3251 5302	− 84 −139	2.6 2.6	37 F.G.	P1-2544 WB-4568	2495 4479	− 49 − 89	1.9 1.9
18 J.D.	P1-3144 WB-4504	3036 4350	−108 −154	3.5 3.5	38 T.W.	P1-2968 WB-4922	2835 4702	−133 −220	4.6 4.6
19 A.P.	P1-3654 WB-4870	3614 4818	− 40 − 52	1.1 1.1	39 I.S.	P1-3123 WB-5816	3063 5704	− 60 −112	2.0 1.9
20 J.P.*	P1-2992 WB-4281	2969 4247	− 23 − 34	0.8 0.8	40 M.L.	P1-3857 WB-5925	3929 6035	72 110	1.9 1.8

*Repeat determinations, utilizing 2 sample technique (1 background sample, 1 determination sample).
Pl = Plasma.
WB = Whole blood.

Mean per cent difference 3.47

plot, and believed that slightly over two-thirds of their cases fell within 10 per cent of the expected normal. They, too, found that the muscular, mesomorphic individual frequently gave the higher values, and the very obese or very asthenic individual the lower values.

This series of 150 cases, utilizing the radioactive iodinated human serum albumin technique for plasma volume and the hematocrit to ascertain total circulating volume, has shown the previously quoted figure of 3.3 liters per square meter of surface area to calculate normal total volume to be considerably higher than our results would indicate. Figure 2 is a graphic representation plotting surface area against blood volume and shows the mean, empirically determined value to be 2.68 liters per square meter; in none of the 150 cases were results as high as 3.3 liters per square meter, and only 10 cases fell within 10 per cent of that figure. On the other hand, 89 of the 150 cases which were plotted fell within 11 per cent of the lower value, and the extremes of range were 20 per cent above and 26 per cent below the aforementioned value.

No patients in this series were in the prepubertal age group, and all but 6 were over 21 years of age. Children present an entirely different problem, with their more active metabolic mass, and, therefore, the data presented do not apply to the very young. The elderly patient, as would be expected, presents the lowest figures, and with only 1 exception, all of the values below 16 per cent of the expected normal were in individuals over 64 years of age. Females have a lower blood volume because of the proportionately greater amount of metabolically inactive tissue, such as fat, and because of their significantly lower total red blood cell mass. In other determinations performed, exclusive of the 150 normals, such factors as venous pressure (aside from frank cardiac failure), blood velocity rate, and other cardiodynamic phenomena apparently seem to have very little effect on the measurable total blood volume.

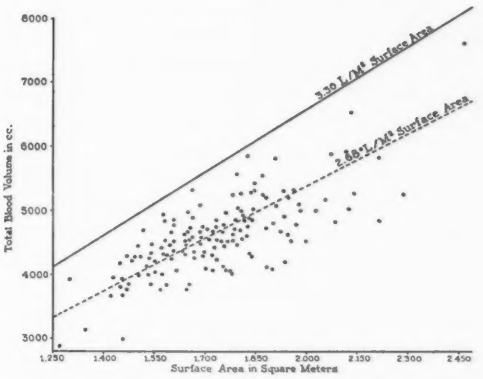

FIG. 2. Comparison of determined blood volumes and calculated "normal" volumes in 150 normal hospital patients on the basis of surface area.

DISCUSSION

Various aspects of the technique employed presented certain unavoidable problems. It was soon found that the linkage of I^{131} and human serum albumin resulted in a protein complex that tends to adsorb on flasks, syringes, needles, and other apparatus. Activity of varying amount is frequently detectable following routine washing of these articles; the most important site is probably in the volumetric glassware, and the adsorbed material could be removed only by vigorous washing with strong cleansing agents (dichromate-sulfuric acid solution), though some of the newer detergent cleansing agents are undoubtedly more efficient. The amount of activity lost can be minimized by always introducing the more concentrated stock solution into one of the diluting agents whenever possible. The syringes used are flushed 3 times with the patient's blood during the injection of the tracer agent, and all test tubes are of the plastic, disposable type.

Sampling techniques have been reported ranging from 1 blood sample at 5 minutes following tracer injection to samples taken every 5 minutes, for 30 minutes. To simplify the procedure and remain within reasonable allowable error, a 15 minute mixing period was allowed, and 1 sample drawn at that time.

The use of the venous hematocrit as an integral part of the determination of the total blood volume probably introduces a most considerable error, and certainly the most constantly present one. As has been described, the specimen should be centrifuged for 30 minutes at 3,000 revolutions per minute, but a significant portion of the cellular column of the tube has been aptly labelled "trapped" plasma, for the cells, due to their semispheroidal shape, do not fit together as blocks, and the interstices are filled with plasma which cannot escape. Estimations of the volume of this trapped fluid vary, and factors used to correct the reading vary from 0.89 to 0.98, most sources quoting 0.95 or 0.96 as the most valid figure. Consequently, 0.96 has been used throughout these determinations, though it is apparent that the separate determination of red cell volume (using Cr^{51}, e.g.) and plasma volume would yield the more accurate total body hematocrit as elaborated by Price. There is considerable evidence to show that the venous hematocrit is not exactly the true total body hematocrit for other cardiodynamic reasons, and, in fact, may be considerably lower. Studies with Cr^{51} are now under way to corroborate this observation.

Another important concept bearing upon this problem is that of "active blood volume" which refers to the important factor of stasis of blood in splanchnic and other pools, with subsequent exclusion from the measurable flow; these reservoirs render blood volume determination, at least at present, rather an approximation. No present values differentiate the circulating blood volume from the total blood volume, but that a real discrepancy may exist should always be taken into consideration.

ILLUSTRATIVE CASES

The following cases are intended to point out that the value of the blood volume determination is based on a knowledge of the expected normal value for a given individual; only subsequent determinations are conceivably comparative.

Case 1. Patient, J. P., a 56 year old white male, was admitted to the male medical service of the Cook County Hospital with a diagnosis of bleeding peptic ulcer. He stated that he had vomited "a gallon" of blood of bright red color, without clots, that morning. Admission hematocrit was 41 per cent, red blood count was 4.6 million per cubic millimeter, and white blood count was 12,600 per cubic millimeter; initial blood volume was 5,870 cubic centimeters (height 152 centimeters, weight 118 kilograms); on the basis of weight alone, this patient would have had an anticipated normal volume of 9,440 cubic centimeters, or a deficit of 3,570 cubic centimeters, roughly 40 per cent of the expected normal volume. On the basis of surface area, the expected normal volume was 6,140 cubic centimeters, or a deficit of 270 cubic centimeters; the patient was treated expectantly, and Levin return changed from coffee-ground to clear, becoming bile-stained in approximately 6 hours. A duodenal ulcer was later shown roentgenographically.

This case shows the potential invalidating of the blood volume determination procedure in an extremely obese individual. If therapy had been governed by the initial standard, massive overtransfusion in the face of a minimal hemorrhage would have occurred.

Case 2. Patient, G. W., a 17 year old negro male, was admitted to the male surgical service of the Cook County Hospital with a 40 per cent second and third degree body burn. The patient was apprehensive, blood pressure was 130/60, pulse 116, and he complained only of thirst. No oral fluids were administered, a saphenous cutdown was performed, and an initial blood volume was 5,310 cubic centimeters (height 193 centimeters, weight 77 kilograms), showing a deficit of only 750 cubic centimeters, on weight alone; utilizing the surface area, however, the expected normal for this individual should have been 7,280 cubic centimeters, an actual deficit of 1,970 cubic centimeters. Therapy was based on the latter figure.

Here the emphasis on the body weight in a tall, muscular, lean individual led to an obvious error in basing the normal on weight alone. This athletic individual obviously should be considered to have a larger, proportionately, "active metabolic mass."

The problem of equating the normal volume in a patient with a recent extensive weight loss is important, and it is better in either case (weight alone or surface area calculations) to substitute the expected normal weight in the formula for the actual weight of the patient. This is especially important in the routine preoperative preparation of patients for surgery, notably those with debilitating diseases.

CONCLUSIONS

The practical approach to the problem of determining blood volumes in a large hospital with a considerable patient load resolves itself into the following points:

1. A simple, reproducible, harmless, sound method for ascertaining single or repeated blood volumes in a given individual is required.

2. The initial and, hence, the subsequent volumes are not really absolute values but are comparative, in the sense that the measured entity is not the true total body volume, but is a reflection of the active circulating mass, and, as such, is subject to variation with the technique of determination employed.

3. If the initial result can be interpreted within 10 to 12 per cent of a given, easily predetermined normal, the technique is useful.

4. A simple weight, or height, or single factorial system is not as satisfactory as one employing two or more factors, but a limit is placed on the complexity of determining the normal for a given patient by practical consideration.

5. The surface area has been found in 150 normal hospital patients admitted for minor procedures to be the single most useful basis for determining the normal total volume when radioactive iodinated human serum albumin is used to calculate the circulating plasma volume, and the total volume is derived utilizing an accurate hematocrit (spun 30 minutes at 3,000 r.p.m. in a Wintrobe tube). It is readily acknowledged that this standard, set at 2.68 liters per square meter of body surface would be in error, to some degree, if Evans blue, radiochromium tagged red cells, or other tracer method were used. At this time, the iodinated albumin labelling of the plasma is the most practical technique available for clinical practice.

6. The simultaneous use of I^{131} to determine plasma volume and Cr^{51} to determine total red cell mass, giving true total body hematocrit and eliminating the factor of trapped plasma, will offer further information about the discrepancies in results with various techniques, and may revise our concepts of the dynamics of the "inactive" circulation considerably.

SUMMARY

The results of blood volume studies in 150 normal hospital patients contrasted with the expected "normal" volume on the basis of weight, and utilizing surface area, has been presented. A critical evaluation of our presently accepted normal, or expected, blood volumes is necessary, and a purely empiric value for the total volume-surface area relationship in the normal has been derived from the study of these 150 patients. Further study with total body hematocrit is expected to shed light on the "reservoirs" of blood storage which probably are not measured as part of the normal circulating volume.

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COMMON DUCT EXPLORATION IN ACUTE CHOLECYSTITIS

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IN THE MANAGEMENT of acute cholecystitis there has been a gradual trend over the past 25 years in favor of early surgical treatment. It would appear that this treatment is continuing because an increasing number of surgeons who have a particular interest in biliary tract disease have reported its accomplishment with a low mortality rate and a reasonable incidence of morbidity of complications following operation. They have thereby reduced the deaths from the complications that may result from acute cholecystitis not treated surgically. At the same time they have relieved many patients of their symptoms and probably in most instances have interrupted the progress of biliary tract disease. Although acute cholecystitis may appear as the first manifestation of disease of the biliary tract, and even in the absence of stones, such is by no means a common occurrence. More often than not the acute phase is superimposed upon a chronic cholecystitis associated with cholelithiasis. One of the sequelae of gallstones is choledocholithiasis and is to be anticipated in acute as well as chronic cholecystitis. Indeed the consequences of overlooking a stone in the common duct in acute cholecystitis may be more quickly disastrous than in chronic cholecystitis. A greater proportion of our population is living into the older age group of 65 years and over each year. Acute cholecystitis is not infrequent in this group and often is of a rapidly fulminating type. Furthermore, it has been repeatedly observed that the longer an individual has gallstones the greater is the likelihood of coexisting choledocholithiasis. For these reasons we consider it appropriate to re-evaluate at this time the problem of common duct exploration in acute cholecystitis.

Whenever a patient is operated upon for disease of the gallbladder the common duct should be examined for evidence of choledocholithiasis. This we believe applies to patients with acute cholecystitis regardless of whether a cholecystectomy or a cholecystostomy is done. The inflammatory reaction that involves the adjacent structures as well as the gallbladder in acute cholecystitis may obscure the findings that are the usual indications for common duct exploration. The acutely inflamed edematous common duct may be easily mistaken for an indurated dilated one such as is usually associated with choledocholithiasis. Stones are more difficult to palpate for the same reason. Jaundice, with acute cholecystitis, is a less reliable indication of common duct stones as it frequently seems to be associated with cholangitis, marked inflammatory reaction of the larger biliary ducts, or sometimes spasm or edema of the sphincter of Oddi. Reluctance to dissect the structures that are somewhat obscured by the inflammatory reaction and the patient's general condition tend to lead to conservatism in exploring the common duct in acute cholecystitis.

In an effort to better acquaint ourselves with these problems we have reviewed the case records of those patients having common duct exploration in the presence of acute cholecystitis at The New York Hospital-Cornell Medical Center from 1932 to 1955. In this 23 year period there have been 4,348 operative procedures for nonmalignant disease of the biliary system. Four thousand one hundred and forty-four of these were cholecystectomies or cholecystostomies (Table I); the remainder were common duct

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explorations, reconstructions of the common duct, cholecystoduodenostomies, cholecystogastrostomies, and other miscellaneous procedures. Eight hundred and seventy-seven patients, or 21 per cent, of the 4,144 had acute cholecystitis, 698 being treated by cholecystectomy alone and 96 by cholecystostomy alone. Eighty-three, or 9.5 per cent, of the patients with acute cholecystitis had exploration of the common bile duct; 81 in conjunction with cholecystectomy and 2 with cholecystostomy. It is with these 83 patients that we will concern ourselves in this report.

TABLE I.—INCIDENCE AND RESULTS

	Chronic cholecystitis	*Acute cholecystitis*	*Total*
Cholecystectomies and cholecystostomies*	3267	877	4144
Choledochotomies	411	83	494
Choledocholithiasis	251	49	300

*Alone and combined with choledochotomies.

TABLE II.—DISTRIBUTION AS TO AGE AND SEX

	Females		*Males*		*Total*	
Age, years	*No.*	*With common duct stones*	*No.*	*With common duct stones*	*No.*	*With common duct stones*
Less than 50	37	27	4	2	41	29
50 and over	30	14	12	6	42	20
Totals	67	41	16	8	83	49

AGE AND SEX

The ages of patients in this series ranged from 22 to 78 years with an average of 49.6 years. Seventy-five per cent of the males were more than 50 years of age, whereas only 45 per cent of the females were over 50 years of age (Table II). As in many of our other case studies (5, 6), we have found cholelithiasis approximately 4 times more frequent in females than males; in this series the ratio was 4.2 to 1.

ASSOCIATED CONDITIONS

Associated conditions have been grouped into those considered to be directly related to the diseased biliary system and those with no apparent relation to disease of the gallbladder or common duct (Table III). In the former group there was 1 patient who was found to have a 1 centimeter cholecystoduodenal fistula. The gallbladder was dissected from the duodenum and the defect in the duodenum closed. The patient did well. Pancreatitis was evident in 3 patients; in 2 this was considered to be chronic and in the other acute.

In 41 of these patients there were 50 associated conditions which, although having no apparent relationship to the gallbladder disease, might have had some influence on the patient's operative or postoperative course. Hypertension, arteriosclerotic heart disease, obesity, and diabetes mellitus which were diagnosed frequently in this series are known to be associated with an increased operative morbidity.

INDICATIONS FOR CHOLEDOCHOTOMY IN ACUTE CHOLECYSTITIS

Jaundice. Although a mild icterus may be caused by cholangitis associated with an acute cholecystitis, frank jaundice with a bilirubin of 1 (icteric index of 10) and over is by far the most frequent indication for exploration of the common duct. Such a degree of jaundice was the primary reason for its being undertaken in 56, or 67.5 per cent, of the patients in this group. However, just as in other phases of biliary tract disease the history of previous episodes of jaundice is also an indication.

Palpation of a stone. Palpation of a stone or stones within the ductal system makes exploration mandatory. Careful palpation has been rewarding often enough to persuade us that it should always be done. Stones were palpated before opening the duct in 11 patients in this series.

Distention of the common duct. An obviously distended common duct should be explored, but in acute cholecystitis this may be difficult to determine because of the inflammatory reaction of the structures in the hepatic pedicle. Palpation of the lower segment adjacent to the duodenum sometimes reveals a compressible dilated structure. Twelve patients, or 14.4 per cent, were considered to have definite common duct dilatation. In general, we think better to err on the side of negative

TABLE III.—ASSOCIATED CONDITIONS—RELATED AND UNRELATED

	No. of cases	*No. of patients*
Related to disease of the biliary system		4
Pancreatitis, chronic	2	
Pancreatitis, acute	1	
Cholecystoduodenal fistula	1	
Unrelated to disease of the biliary system		41
Hypertension	7	
Arteriosclerotic heart disease	7	
Obesity	7	
Diabetes mellitus	5	
Varicose veins	5	
Benign prostatic hypertrophy	2	
Osteomyelitis	2	
Nontoxic nodular goiter	2	
Hepatic cyst	1	
Diverticulitis	1	
Dermoid cyst ovary	1	
Fibromyoma of uterus	1	
Inguinal hernia	1	
Pregnancy	1	
Carcinoma of the tongue	1	
Rheumatoid arthritis	1	
Erythema nodosum	1	
Pulmonary emphysema	1	
Rheumatic heart disease	1	
Bronchitis	1	
Cystorectocele	1	

exploration rather than on that of overlooking calculi.

Edema. Edema about the head of the pancreas and minimal induration alone need not be considered indications for exploration. However, if present with any other indication, they assume greater significance and are evidence in favor of stones. Extensive induration of the pancreas requires common duct exploration.

Small stones in the gallbladder or cystic duct. The number, nature, and size of stones in the gallbladder and the presence or absence of calculi in the cystic duct should be determined by the surgeon. A dilated cystic duct and small stones without obstruction of the former, although relatively infrequent in acute cholecystitis, are commonly associated with choledocholithiasis. However, in our experience common duct stones have not been recovered as frequently in those patients with acute cholecystitis as in those with comparable small stones with chronic cholecystitis.

JAUNDICE

Fifty-six patients of this series had either an icteric index or a bilirubin determination preoperatively. In order to compare the degree of jaundice to the incidence of stones we have divided the bilirubin and icterus index values into 3 groups (Table IV). We realize that the bilirubin and icterus index cannot be accurately compared, but for the sake of simplicity in presenting the data we have considered the icterus index value to be 10 times as great as the bilirubin value. Two of the 5 patients who had values considered normal by our standards had common duct stones. In 16, or 59.3 per cent, of the patients with slight to moderate icterus and in 14, or 58.3 per cent, of the patients with marked icterus stones were recovered from the common duct.

INCIDENCE OF CHOLEDOCHOLITHIASIS

Of the patients in this clinic with acute cholecystitis 9.5 per cent had a choledochotomy in addition to a cholecystectomy or a cholecystostomy (Table I). Of the 83 such patients making up this series in 49, or 59.0 per cent, stones were recovered from the common duct. Thus 5.6 per cent of the 877 patients with acute cholecystitis were found to have choledocholithiasis. Of 3,267 patients having cholecystectomy or cholecystostomy for chronic cholecystitis, 411, or 12.5 per cent, had a common duct exploration. Of these 411 patients, 251, or 61.1 per cent, had choledocholithiasis. Thus 7.7 per cent of the 3,267 patients with chronic cholecystitis were found to have common duct stones.

MORBIDITY AND MORTALITY

Complications occurred in 15 patients, or 18.0 per cent (Table V). Bronchopneumonia developed in 5 and wound infection in 4 patients during the postoperative period. Cholangitis, paralytic ileus, thrombophlebitis, pulmonary atelectasis, diabetic acidosis, electrolyte imbalance, upper gastrointestinal hemorrhage, and urinary obstruction each accounted for 1 complication. Two patients of this group had 2 complications. There were 4 patients with retained common duct stones, 2 being found at autopsy and 2 at re-exploration of the common duct. In addi-

tion there were 2 patients who had persistent jaundice following operation, 1 for 37 days and 1 for 42 days. Neither of these were proved to have a retained common duct stone. One was followed 8 years before dying of a heart attack with no further symptoms of common duct stone. The other is well 14 years following surgery.

There were 2 deaths, a mortality of 2.4 per cent. One occurred in a 63 year old white male admitted to The New York Hospital-Cornell Medical Center on June 12, 1933 with a 2 month history of right upper quadrant pain and varying degrees of jaundice. On examination he was mildly icteric and had right upper quadrant tenderness. Urinalysis revealed a 4+ Benedict's reaction. White cell count was 5,700; icteric index was 16 units; and fasting blood sugar 150 milligrams per cent. A Graham's test revealed a faintly opacified gallbladder. Because of these findings 48 hours were devoted to the preparation of the patient. At operation there were dense adhesions involving the gallbladder, duodenum, and common bile duct. Numerous stones were palpated in the gallbladder and the common duct was dilated and thickened. After a cholecystectomy had been performed the common duct was explored, and numerous stones were removed. The surgical pathologist's report was acute cholecystitis with cholelithiasis. Following operation there was a fluctuation of temperature to 38 degrees C. each night. The diabetes was well controlled with insulin. Drainage from the cigarette drains placed down to the foramen of Winslow was unremarkable, and on the sixth postoperative day they were removed. Clear bile drained from the T tube. There was no evidence of increased pressure by the bedside burette; therefore, on the tenth postoperative day the T tube was removed. No cholangiogram was taken. During the ensuing 2 weeks 30 to 60 cubic centimeters of a purulent material drained daily from the T-tube site. Daily saline irrigations of the sinus tract were followed by a gradual decrease in the amount of drainage and return of the temperature to normal. His course was considered to be satisfactory until the fifty-first day following surgery when he suddenly became dyspneic and cyanotic and quickly expired. Death was attributed to pulmonary embolus and myocardial infarction. Autopsy revealed a large subphrenic abscess, 2 stones in the common duct, bronchopneumonia, cirrhosis of the liver, and fibrosis of the myocardium.

TABLE IV.—JAUNDICE IN RELATION TO CHOLEDOCHOLITHIASIS IN 56 PATIENTS EVALUATED BY ICTERIC INDEX OR BILIRUBIN DETERMINATION

Icterus index	*or*	*Bilirubin*	*Choledocholithiasis*	
units		*units*	*Present*	*Absent*
Less than 10		Less than 1	2	3
10–30		1–3	16	11
Greater than 30		Greater than 3	14	10

The other death occurred in a 54 year old white female admitted to The New York Hospital-Cornell Medical Center on August 31, 1944 with a 3 day history of nausea, vomiting, and intermittent crampy abdominal pain most severe in the right upper quadrant. The day before admission she had noted a slight yellow tinge to her skin. She had been known to have mild diabetes mellitus for 1 month before admission. On examination there was marked right upper quadrant tenderness. The temperature was 38 degrees C., white cell count was 13,500 with 82 per cent polymorphonuclear leucocytes, icteric index was 24 units, and fasting blood sugar 383 milligrams per cent. Diabetic acidosis which was evident on admission was readily corrected. At operation, 48 hours after admission, a large tense thickened gallbladder containing stones was found. The common duct in the opinion of the surgeon was not dilated. Following removal of the gallbladder further examination revealed 2 stones, 6 millimeters in diameter, palpable in the remaining portion of the cystic duct. These were removed and a probe and then a catheter introduced through the cystic duct in an effort to demonstrate the presence or absence of stones within the common duct. It was concluded that none was present. After ligating the cystic duct near its junction with the common duct a cigarette drain was placed down to the foramen of Winslow;

TABLE V.—INCIDENCE AND RESULTS AS REPORTED BY 8 REPRESENTATIVE AMERICAN CLINICS, 1947 TO 1956

Author	*No. of patients*	*Choledochotomy*		*Choledocholithiasis*	
		No.	*Per cent*	*No.*	*Per cent*
Lester—1947(8)	96*	7	7	5	71
Dunphy—1949(4)	134	56	42	28	50
Holden—1952(7)	315	57	18	22	39
Borland—1952(2)	108	13	12	5	38
Ochsner—1955(9)	468	130	28	51	39
Boyden—1955(3)	105	27	26	16	59
Bartlett—1955(1)	592	154	26	66	43
Present series	877	83	9.5	49	59
Total	2695	527	19.5	242	45.9

*This does not include 13 patients in this series who had cholecystostomy.

no drainage of the common bile duct was employed. On her first postoperative day the temperature rose to a maximum of 39.3 degrees C. There was dullness and decreased breath sounds over the right lower lung field area leading to a diagnosis of pneumonia. Sulfadiazine, 5 grams a day, intravenously was begun. The temperature continued to rise each evening and on the third postoperative day for the first time there was a copious amount of bile drainage from and about the cigarette drain. Penicillin, 240,000 units a day, was then given in addition to the sulfadiazine. The diabetes became increasingly difficult to control. She continued to become progressively worse in spite of the addition of supportive measures including transfusions of whole blood, maintenance of water and electrolyte balance, and oxygen. She slowly deteriorated and quietly expired on the ninth postoperative day. Autopsy revealed residual stones in the common and hepatic ducts with leakage of bile from the cystic duct and a large subphrenic abscess. There was marked fatty infiltration of the liver.

Both of these patients who died are examples of severe infection in diabetics over 50 years of age. And while this unfortunate combination of factors played a role, the primary contributing cause of each patient's death was apparently the retained common duct stones resulting in a biliary fistula with leakage of bacteria-laden bile into the operative area with extension to the subphrenic space. In the second patient there were 2 errors. First, the common duct was inadequately explored and second no decompression drainage of the common duct was employed. Exploration of the common duct should be embarked upon when it is believed that it contains stones. Stimulated by this consideration a meticulous, careful, and thorough exploration should be done. The duct cannot be explored satisfactorily through the cystic duct, rather an adequate incision in the common duct is to be employed. And although this procedure greatly facilitates the various maneuvers that different surgeons may employ in searching for common duct stones some may still escape detection. Following common duct exploration a T tube or catheter should be employed to establish drainage and maintain decompression of the ductal system. A retained common duct stone following choledochotomy without decompression drainage is frequently disastrous just as in these 2 patients who died. Such drainage should be maintained for 8 to 10 days or longer, and the catheter or T tube should not be removed until it has been demonstrated by the bedside burette test that bile flows into the duodenum without evidence of obstruction or increased pressure and followed by a cholangiogram that reveals no evidence of retained stone.

Operation was delayed for a period of 48 hours for each of these 2 patients. Early operation is desirable because of the impending likelihood of gangrene, perforation, and dissemination of infection, particularly in the older age group. We believe that most patients, including diabetics, can be adequately prepared for operation within 24 hours. It is our present policy to operate upon patients with acute cholecystitis as soon as they have been adequately prepared unless there is some contraindication to operation.

OPERATIVE TECHNIQUE

The operative technique will necessarily vary with the individual patient; however, we have found the one to be described applicable to the majority of the cases with mini-

mal danger of damaging the structures of the hepatic pedicle. A right subcostal incision is usually employed. This provides good exposure and facilitates a secure closure. However, in patients with a narrow costal arch, or when the diagnosis is in question, an incision over the right rectus that permits reflection or splitting of the muscle should be used.

After entrance into the peritoneal cavity of acute cholecystitis only a limited exploration is performed because of the danger of spreading irritating bile-containing material or infection. The practice of placing a hand between the diaphragm and liver in an attempt to displace the liver inferiorly is, we think, to be discouraged because it predisposes to dissemination of infected material and the development of subphrenic abscess. Adequate exposure of the gallbladder and common duct area is essential. Should the gallbladder be too distended to permit good exposure it is decompressed by aspiration with a trocar attached to suction. We favor removal of the gallbladder from the fundus toward the cystic duct because it is believed that there is less likelihood of injuring the common duct. This we accomplish by first identifying the cystic duct and dissecting it to its junction with the common duct. A ligature is then placed about it for identification and traction. Next the cystic artery is dissected free to its origin, usually from the right hepatic, and then temporarily occluded by ligature near its junction with the wall of the gallbladder. The gallbladder is then dissected from the fundus downward exercising great care to stay within the capsule of the gallbladder bed and not to injure the liver. If scarring is present it is considered preferable to open into the gallbladder rather than to penetrate the capsule or injure the liver. The temporary occlusion of the cystic artery renders this a relatively bloodless procedure. As the cystic artery is encountered it is secured and permanently ligated.

The common duct is then thoroughly examined. It should be well visualized and palpated throughout its course. The head of the pancreas is palpated to determine the presence of induration. Should there be an indication for exploration of the common duct it is embarked upon at this point. If a cholangiogram is to be taken, the cystic duct is opened .5 centimeter proximal to its junction with the common duct and a rubber catheter is inserted (Fig. 1A). The cholangiogram is then taken. We do not routinely take cholangiograms before exploration of the common duct but if no stones are palpated it may be of aid in localizing them.

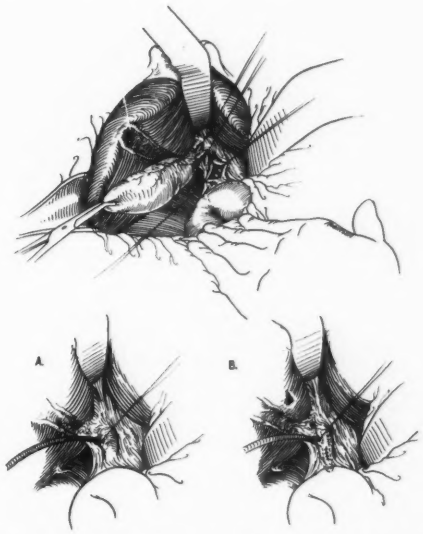

FIG. 1. The gallbladder has been removed from the fundus downward exposing the cystic artery and duct. The common duct has been opened revealing choledocholithiasis. Insert A, If a cholangiogram is to be taken a catheter is inserted into the cystic duct prior to opening the common duct. Insert B, The long arm of the T tube is brought out through the cystic duct remnant and the opening in the common duct is closed.

To explore the common duct a longitudinal incision is made usually just below the junction with the cystic duct for a distance of 3 centimeters (Fig. 1). Stay sutures of fine silk are then placed to facilitate the various maneuvers to be utilized. Stones are removed as encountered. The common duct distal to the incision is first explored. We use the malleable Cushing pituitary scoops shaping the handle to conform with the apparent

course of the duct. Palpation of the duct over the spoon, particularly within the duodenal segment, sometimes reveals concealed calculi. Following this an attempt is made, by using gentle pressure, to pass the spoon through the ampulla of Vater and demonstrate its presence within the duodenum. Thereafter, the proximal biliary radicals are explored. Catheters, woven bougies and probes, and irrigating devices may be used with varying degrees of success. More important than any mechanical device, however, are the experience and ingenuity of the surgeon. But even he with the best of facilities may overlook a stone.

The ductal system should then be thoroughly and repeatedly irrigated with saline to remove all debris and clots of blood. One should be able to pass a firm rubber catheter through the ampulla of Vater at this point and establish the patency of this structure. Following the exploration of the common duct, drainage may be established either by using the remnant of the cystic duct for the exit of a catheter or long limb of a T tube, or by employing the incision in the common duct. In any instance, it is important to provide a bile tight closure about the drainage tube so that bile will not escape into the surrounding area. If one elects to use the cystic duct remnant, the catheter or long arm of the T tube is secured with a ligature of No. 00 plain catgut placed around the cystic duct 3 millimeters from the junction with the common duct and a fine No. 000 silk transfixion suture through the T tube and proximal portion of the cystic duct remnant (Fig. 2). The opening in the common duct is closed with fine interrupted sutures (Fig. 1B). Another cholangiogram is then taken through the T tube. If the operator is satisfied that there are no additional stones a cigarette drain is placed down to the foramen of Winslow and this and the T tube are brought out along the gallbladder bed and through a stab wound. The abdominal wound is then closed.

For the first few days following operation these patients are usually given penicillin, streptomycin, and sometimes terramycin. They are immediately ambulated. The cigarette drain is removed from the seventh to the tenth postoperative day depending on the amount of drainage. Prior to removal of the T tube it is important to demonstrate that there are no retained stones, and that the common bile duct is patent with free flow of the contrast material into the duodenum. Usually on the evening of the eighth postoperative day we attach the T tube to a 30 centimeter burette attached to the head of the bed and have the patient sleep flat through the night. Should there be obstruction the fluid level will rise in the burette. A cholangiogram through the T tube is then performed. If this reveals no abnormalities and if the patient tolerates 24 to 48 hours with the T tube clamped with no pain or discomfort, the tube is removed.

Decompression of the common duct and a postoperative cholangiogram prior to removal of the decompression tube are essential steps following common duct exploration. We support this view by the fact that both of the patients in this series who died had inadequate common duct drainage; one having no common duct drainage and the other having the T tube removed in the presence of retained common duct stones.

If the patient is in such poor condition that cholecystectomy would not be tolerated, a cholecystostomy should be performed. Should there be a stone obstructing the common duct proximal to the cystic duct, cholecystostomy would not relieve the obstruction. Therefore, common duct exploration, if indicated, should be performed in conjunction with cholecystostomy. The additional increment upon the patient's capacity to tolerate surgery is justified by the possible benefit to be gained.

DISCUSSION

The indications for exploration of the common duct in acute cholecystitis seem to vary among a number of clinics throughout the country from the reports published (Table V). Although each patient must be treated as an individual problem, there are

certain general criteria for choledochotomy in acute cholecystitis which should be reemphasized. A specific indication should be required in each case, and the procedure not be undertaken haphazardly. We agree with Lester that jaundice alone is not necessarily an adequate indication. However, in patients who have had repeated attacks of jaundice, progressive jaundice, or who have a markedly elevated bilirubin, the common duct should be explored. In addition, exploration should be performed in the presence of the following conditions: (1) palpation of a stone or stones within the ductal system; (2) distention of the common duct; (3) edema about the head of the pancreas (if present with any other indication for exploration), and extensive induration of the pancreas; and (4) small stones in the gallbladder or cystic duct.

Of the 56 patients who had a choledochotomy because of the presence of jaundice, stones were not found in the common duct in 37.5 per cent. Slight icterus may be the result of a cholangitis associated with the acute inflammatory process. However, as these data indicate (Table IV) an icteric index of over 10 units or a bilirubin of over 1 unit was accompanied by stones in around 60 per cent. The incidence of stones does not seem to vary with the degree of jaundice for this series. It should be emphasized, however, that in patients with choledocholithiasis with previous intermittent common duct obstruction complete obstruction may occur during an acute episode. It has been observed that stones are sometimes firmly impacted in the distal portion of the common duct with considerable edema of the wall just proximal to them. Edema of the duct proximal to the duodenum in the presence of jaundice (icteric index greater than 10 units or bilirubin greater than 1 unit) has so frequently been associated with stones in this location that we believe it a significant finding that should always be looked for during an operation for acute cholecystitis.

Due to the edema and thickening of the surrounding tissues, palpation of stones and

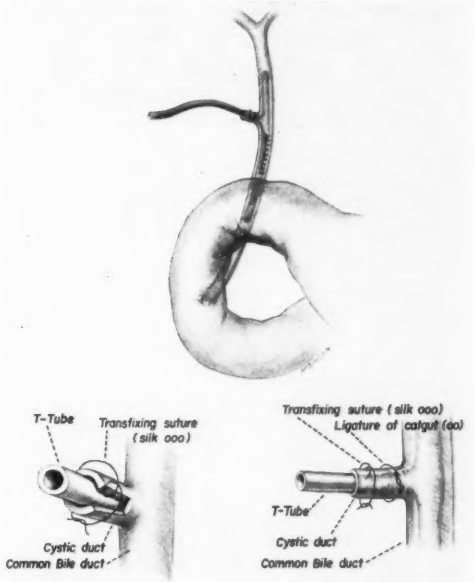

FIG. 2. The long arm of the T tube is brought out through the cystic duct and secured with a ligature of No. 00 plain catgut placed around the cystic duct 3 millimeters from the junction with the common duct and a fine No. 000 silk transfixion suture through the T tube and proximal portion of the cystic duct remnant. The common duct is closed with fine suture material, catgut or silk.

evaluation of induration or dilatation of the common duct and cystic duct may be difficult. Should there be any question in the surgeon's mind regarding the evaluation of the cystic or common duct, these structures should be exposed as has been described. The additional short period of time used in the dissection of these structures should not increase the postoperative morbidity and may be rewarding in preventing the serious complication of a retained common duct stone.

If a frank acute pancreatitis is found in association with acute cholecystitis the common duct should be explored. In a study of 100 cadaver or autopsy specimens Sterling found the pancreatic duct joining the common duct in the upper third of the papilla in 3 per cent and in the middle third of the papilla in 14 per cent. He concluded that

intraductal reflux following a stone impacted in the common channel might occur in 15 per cent of patients. Reflux of the bile containing bacteria under pressure into the pancreatic duct would seem to be a likely cause of pancreatitis in patients with acute cholecystitis. In this series only 1 patient had acute pancreatitis as evidenced by widespread fat necrosis extending into the lesser omental sac. Although no stones were recovered from the common duct there is good reason to believe she may have previously passed a stone. Following admission she had had rapidly decreasing jaundice, and at the time of surgery the common duct was markedly dilated and its wall thickened. No common duct stones were found in the 2 patients in this series who had evidence of chronic pancreatitis. Patients with chronic pancreatitis tolerate choledochotomy well and should have the benefit of a careful exploration of the common duct if the surgeon believes calculi are present.

About 50 per cent of these patients had diseases or findings that could conceivably alter the patient's course unfavorably (Table III). A majority of these conditions were ones usually associated with advancing age such as hypertension, arteriosclerotic heart disease, diabetes mellitus, varicose veins, and so forth. We would like to emphasize that although we strongly advocate elective cholecystectomy for cholelithiasis we are operating upon acute cholecystitis in an ever-increasing age group. In the series of acute cholecystitis reported from The New York Hospital-Cornell Medical Center in 1951 (5), 40 per cent were above the age of 50 years whereas in a continuation of the same series in 1955, 48 per cent were over the age of 50. It is evident that a continued effort on the part of the physician is needed in educating patients on the advantages of elective cholecystectomy for cholelithiasis.

On comparing this series of common duct explorations in acute cholecystitis to some of the recent ones reported from other clinics it is evident that the incidence of exploration of the common duct in this clinic is relatively low. Choledochotomy was performed in 9.5 per cent of this series whereas in other clinics it was carried out in as many as 42 per cent of the cases. We do not believe that one should be unduly conservative in exploring the common duct but that the procedure should be carried out only when specifically indicated. Choledochotomy carries with it an increased postoperative morbidity; 18.0 per cent of the patients in this series had postoperative complications. Increasing the length of anesthesia as well as the further dissection of the inflamed tissues required in performing a choledochotomy add to the number of complications. Such complications as bronchopneumonia, wound infection, paralytic ileus, and cholangitis may in part be attributed to these factors.

We are persuaded that we should seek more carefully for the indications for exploration in acute cholecystitis. Certainly if our more elderly patients continue to increase in proportion we may anticipate a higher incidence of associated common duct calculi. Furthermore if choledocholithiasis is strongly suspected common duct exploration becomes mandatory. Once embarked upon, it should be thorough using varied techniques and all available facilities in an effort not to overlook calculi or calcareous material. For us the technique described has provided liberal exposure and ready identification of the important structures in Calot's triangle with minimal danger of damage to them. Although the patients in this series were of comparable age to those having cholecystectomy or cholecystostomy alone the mortality rate is almost identical. Perhaps our over-all armamentarium has added safety for those patients undergoing common duct exploration in acute cholecystitis. Over the past 11 years and for the last 30 patients it has been accomplished without a postoperative death.

SUMMARY

1. The usual indications for choledochotomy are both less easily recognized and not as reliable in the presence of acute chole-

cystitis. Jaundice is frequently unassociated with choledocholithiasis; dilatation and induration of the common duct are hard to evaluate because of the marked inflammatory reaction, and stones are more difficult to palpate for the same reason.

2. Although the increased morbidity associated with exploring the common duct in the presence of acute cholecystitis lends to conservatism, the surgeon must be thorough in evaluating each patient's findings. Retained common duct stones are frequently disastrous.

3. Once the decision is reached to explore the common duct exploration should be performed in a systematic and meticulous fashion. A technique of cholecystectomy and choledochotomy has been described which allows for liberal exposure of the hepatic pedicle and ready identification of the important structures in Calot's triangle with minimal danger of damage to them.

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RESTORATION OF QUADRICEPS FUNCTION IN NEGLECTED TEAR OF THE PATELLAR TENDON

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THE FIBROUS STRUCTURE connecting the inferior pole of the patella to the tubercle of the tibia is variously called tendon or ligament. It bears close structural resemblance to a tendon yet serves as a ligament since it binds two bones, spans a joint, and does not directly connect with any muscular fiber; but if we concede to the generally accepted concept that the patella is a sesamoid bone within the common tendon of quadriceps group of muscle, the so-called ligamentum patellae should be rightly regarded as a continuation of that tendon and named accordingly. It is best to abide with the distinction according to which the tendinous structure proximal to the patella is called quadriceps tendon and the one distal to it is called patellar tendon.

The patellar tendon may tear loose from its proximal or distal attachments and it may even rip through its own substance. In our experience it most commonly becomes avulsed from the inferior pole of the patella and not infrequently pulls off a small ossicle from that bone. It is perhaps more correct to say that the tendon remains stationary and the patella is pulled upward by the quadriceps group of muscles since the patellar tendon is static and cannot contract while the muscles are dynamic and do contract.

Changes accompanying old neglected tear of the patellar tendon. In ancient, unrepaired avulsions of the patellar tendon several sequelae intervene which must be taken into account in efforts directed toward restoration of quadriceps function: the quadriceps group of muscles undergo atrophy of disuse and lose their tone; the patella is pulled up on the femur and later becomes transfixed to the front of that bone by firm, fibrous bands; the unused articular surfaces of the patella and of the corresponding portion of the intercondylar notch of the femur yield to degenerative changes and become rough; the suprapatellar pouch of the knee is filled with adhesions and obliterated; distally the torn end of the patellar tendon seals with scar and its main body shrivels and shreds; occasionally calcific deposits due to old hemorrhage may be seen within the core of the patellar tendon.

Some of these secondary changes, as for instance the retraction of the patella and the atrophy of the quadriceps group of muscles, are reversible. Others, like the degeneration of unused hyalin surfaces and the fraying and calcification of the torn patellar tendon, cannot be helped.

Efforts directed toward bringing the patella down and restoring the strength of the quadriceps muscles. Prior to attempts at repair of the torn tendon the patella and the attached muscles should be mobilized and provision should be made for exercises and strengthening of quadriceps group of muscles.

At a preliminary surgical sitting, through a small lateral parapatellar incision, a sharp chisel is directed under the patella. It is pushed medially and upward, hugging the front of the femur, until all the adhesions binding the patella and the quadriceps tendon are released. Hemostasis is secured and the incision closed. A Kirschner wire is then passed through the proximal patella, from side to side. Postoperatively this wire is hooked to a weight and pulley arrangement in order to overcome the contracture of the quad-

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riceps muscles and bring the patella down into the intercondylar notch of the femur, and also to enable the patient to practice quadriceps setting exercises against tension so that the atrophied muscles recover some of their tone and contractility.

When the quadriceps muscles have regained a measure of their lost power and—as ascertained by roentgenograms—the patella has descended to an inch from the level of the superior articular surfaces of the tibia, the repair of the torn tendon is undertaken.

Repair by substitution. Torn and scarred, and at times calcified, the patellar tendon cannot be mobilized and stretched to span the gap between its severed surface and the inferior pole of the patella; nor can it be relied upon to hold sutures under tension. In an old neglected tear it is much easier, surely more effective, to supplant the torn patellar tendon with a kindred structure.

In the past, long strips of fascia lata have been used as free pedicled grafts. From the medial and lateral borders of the quadriceps tendon two bands have been fashioned, hinged on their attachment to the patella, turned distally, and hooked to the tibial tubercle. The tendon of semimembranosus —already attached to the tibia distally—is detached from its muscular fibers behind the medial condyle of the femur; it is brought to the front and implanted into the patella. We prefer to use the tendon of the semitendinosus which is also attached to the tibia distally but, as compared to semimembranosus, it yields a longer tendon that can be threaded through the tibial tubercle, made to go up to the patella and returned to itself, thus completing a full circuit.

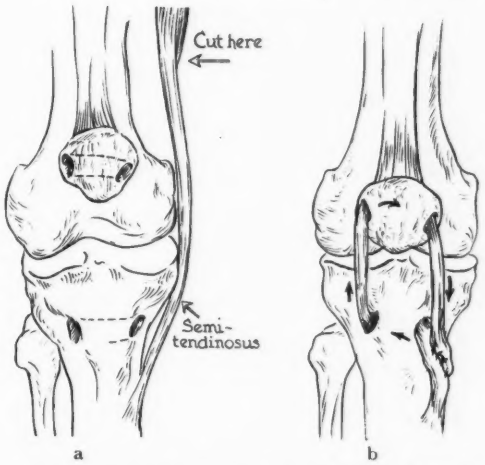


FIG. 1. Drawing illustrating the substitution of the torn patellar tendon by the tendon of semitendinosus. a, The level of detachment of the semitendinosus from the muscular fibers. Note also the tunnels drilled under the tibial tubercle and through the patella. b, The semitendinosus tendon is passed through the drill holes and it is brought back and sutured to itself to complete a circuit.

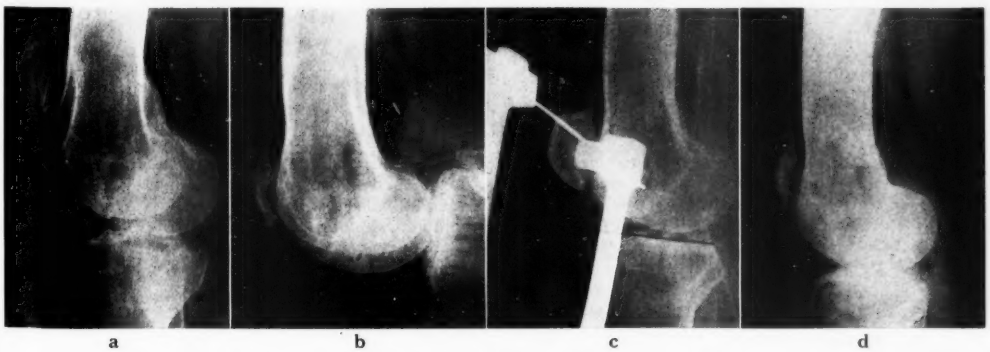
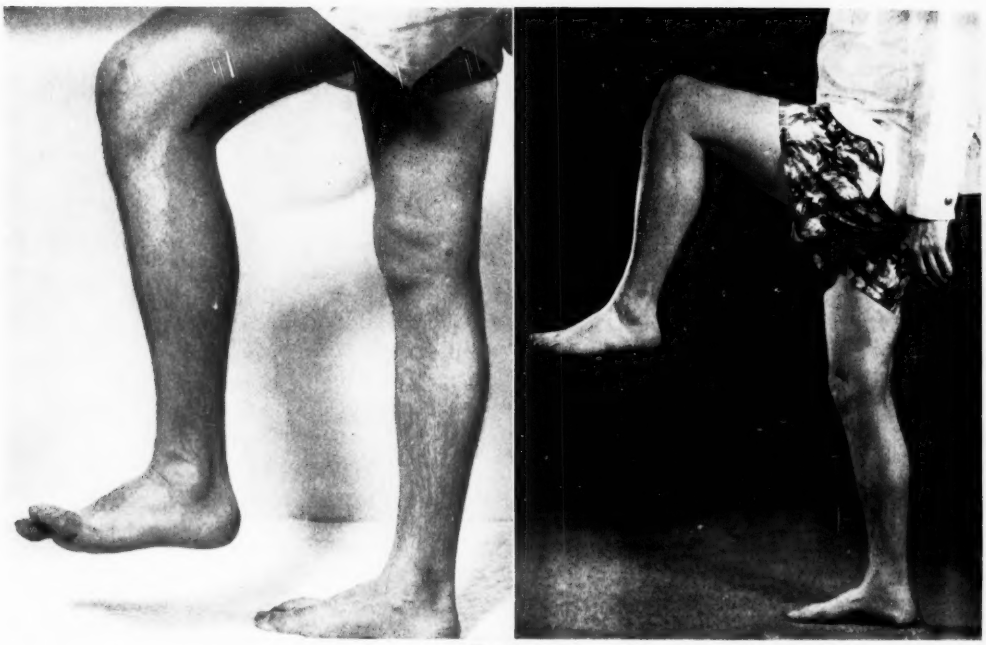
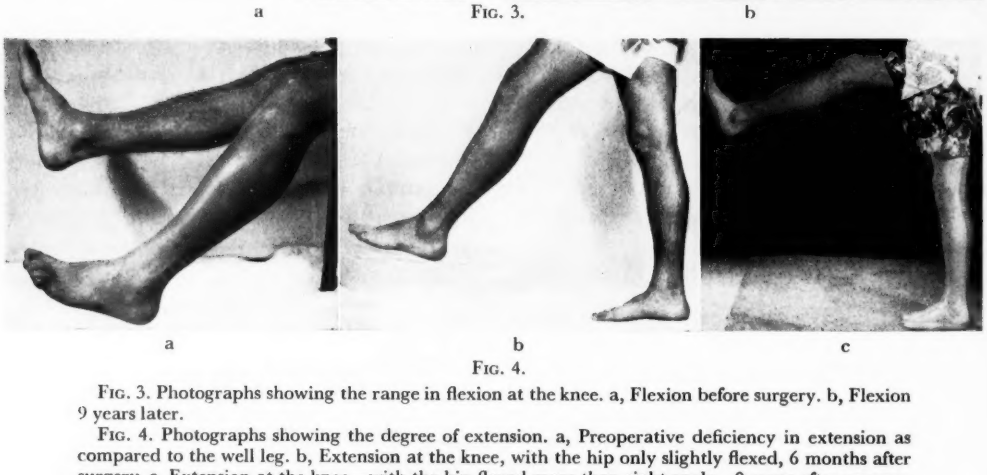


FIG. 2. The shift in the position of the patella as seen in roentgenograms. a, Preoperative position of the patella with the knee in extension. b, The same with the knee flexed. c, The descent of the patella after the bone and the attached tendon have been freed from the femur and skeletal traction has been started with 10 pounds of weight. d, The position of the patella 6 months after operation. Compare this with a.



a FIG. 3. b



a b c

FIG. 4.

FIG. 3. Photographs showing the range in flexion at the knee. a, Flexion before surgery. b, Flexion 9 years later.

FIG. 4. Photographs showing the degree of extension. a, Preoperative deficiency in extension as compared to the well leg. b, Extension at the knee, with the hip only slightly flexed, 6 months after surgery. c, Extension at the knee—with the hip flexed more than right angle—9 years after surgery. The apparent deficiency in extension of the knee is due to the stretch put on the hamstrings. When the hip is flexed the hamstrings become taut and prevent the knee from being fully extended especially in a man of 55 years of age, as the patient was when the photograph was taken.

The Kirschner wire through the proximal patella, introduced at the first surgical sitting, is disconnected from the traction outfit and accorded the same preoperative cleansing care as that given the leg which is to be operated upon.

At this second surgical sitting, through a small transverse incision over its musculotendinous junction the tendon of the semitendinosus is severed. The distal portion of the cut tendon is pulled out through another incision over the insertion of the semi-

tendinosus on the medial aspect of the upper tibia. The patella and the tubercle of the tibia are then exposed through a paramedial vertical incision. Drill holes—commensurate to the size of the semitendinosus tendon—are tunneled, from side to side, through the distal third of the patella and under the tibial tubercle. The free end of the semitendinosus tendon is passed through the tunnel in the tibial tubercle, going from the medial to the lateral side, and then up to the drill hole in the patella through which it is threaded in reverse direction, from the lateral to the medial side. The end of the tendon is finally brought down and sutured to its own stem or to a pedicle fashioned from one of the neighboring tendons, the sartorius or gracilis, which inserts in the same area on the medial aspect of the proximal tibia (Fig. 1).

The incisions are closed and the extremity is encased in a long cylinder cast incorporating the original Kirschner wire through the patella. One may insert another transfixation pin through the tibia farther down and incorporate it also in the cast. The cast and the pins are removed in 6 weeks and functional exercises are started.

The ensuing report of a case with accompanying illustrations will perhaps clarify some of the points which may have remained moot.

REPRESENTATIVE CASE

An adult male, aged 45 years, robust and athletic in 1944 suffered a fracture of the left femur at about the junction of the middle and lower thirds and also an avulsion of the lower pole of the patella on the same side. For the injury he received his earlier treatment elsewhere—not by us. From the information we could gather that the femoral fracture had been managed by skeletal traction for a period of 4½ months. After 9 months from the injury the piece of bone torn loose from the inferior pole of the patella had been resected, with no attempt at anchoring the avulsed tendon to the patella.

When the patient consulted us in 1946—2 years after the injury—he presented definite evidence of continued disruption of the patellar tendon. He complained of difficulty in climbing up the stairs and in walking fast. He was unable to run as was his wont since he was athletically inclined. He realized he could not fully extend or flex his left knee, and the muscles of the thigh just above felt weak and tight.

a b

FIG. 5. Frontal view photographs of both lower extremities. The leg on the left of each picture represents the patient's right and the one on the right, the patient's left or injured limb. a, Preoperative photograph; compare the tapering of the line marking the inner borders of both thighs, and note the prominence and the higher position of the bulge produced by the patella on the right. (The patient's left injured limb.) Note also the depression below the patella marked by a transverse scar. b, The same 6 months after operation.

Examination revealed atrophy of the quadriceps muscles on the left side and fixation of the patella; flexion at the left knee was less than a right angle; when sitting on a chair the patient could raise his leg to 45 degrees from full extension. A lateral view roentgenogram, taken in extension of the knees, showed the left patella to be riding about an inch higher than the right; on flexion of the knee the tibial tubercle appeared to move farther away from the inferior border of the patella.

The patient was admitted to the Wesley Memorial Hospital and operated upon by one of us (Kelikian). In the course of surgical exploration, the patella of the injured limb was found firmly bound to the femur. The suprapatellar pouch of the knee was filled with adhesions, and the quadriceps tendon was stuck to the underlying bone. The patella and the attached tendon were freed from the femur, hemostasis was secured, the wound was closed, and a Kirschner wire was passed through the proximal half of the patella. Postoperatively, a 5 pound weight was connected to the traction pin and the patient was advised to practice quadriceps setting exercises. As checked with roentgenograms, 5 pounds of weight did not alter the position of the patella, but 10 pounds brought it down. It took 13 days of traction and vigorous exercises to

mobilize the patella sufficiently and to restore some tone in the quadriceps group of muscles. At the end of this period the patient was subjected to the second operation—that of substituting the torn patellar tendon with the tendon of the semitendinosus. Postoperatively, a long cylinder cast was applied on the leg incorporating the previously inserted Kirschner wire through the patella. The cast and the pin were removed within a period of 6 weeks and functional exercises were started.

When last seen in 1955—9 years after surgery—this patient could flex his knee to more than a right angle and extend it almost fully. He had no pain in the knee and no tired feeling in the thigh, and he could run and climb stairs without any difficulty whatsoever (Figs. 2 to 5).

EXPERIENCES IN THE SURGICAL MANAGEMENT OF INTRACRANIAL SUPPURATION

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DURING THE PAST 12 YEARS, 45 patients with epidural, subdural, and brain abscesses have been treated on the neurosurgical services of Wayne University. In 2 instances death supervened before operative removal of the intracranial suppuration. Several papers have been written on part of this material (3, 4); the last contribution summarizes the literature and our experiences with 23 cases of civilian intracranial abscesses (7). Since then we have had 22 more patients with intracranial suppuration, and the present article is a summary of our experiences in the management of this series of 45 cases. Important, recent contributions in the literature include the papers of Harpman, Pennybacker, Ballantine and White, and Botterell and Drake.

In the 22 instances since 1950, there were 6 examples of subdural empyema, 1 of epidural abscess, 1 of cortical ulceration with subdural suppuration, and 14 instances of intracerebral abscesses. One of these patients had multiple abscesses. An angiogram done on this patient was not diagnostic; he succumbed several hours later. Autopsy showed 12 or more areas of suppuration in the cranial cavity. There was a fairly large collection in the right temporal lobe (Case 22) but it was not large enough to show in the angiogram. In this group of 22 patients, there were 4 deaths, 1 was among 4 patients in whom excision of the abscess was carried out, 2 occurred among those with trephine, tap, and penicillin instillation, and 1 occurred without removal of any pus. In the group reported in 1950 there were 5 deaths among 23 patients.

From the Wayne State University Neurosurgical Service, and The Grace and Detroit Memorial Hospitals, Detroit, Michigan. Aided by a grant from the Kresge Foundation.

MATERIAL

Table I is a summary of the 22 cases in this study, and Table II is a summary of the 6 cases of subdural abscess. It is interesting to note that ear infection as a cause of brain abscess is not important as formerly. Paranasal sinus disease and blood-borne infections constitute the major causes of intracranial suppuration. Some unusual organisms have been cultured. The material will be further analyzed under the headings of subdural, epidural, and intraparenchymatous abscesses.

Subdural abscess. In the group reported in 1950 there were 4 examples of subdural abscesses. In 1 case it was bilateral. In 3 instances there was an associated intracerebral abscess. In the present series, there are 6 examples, and in 1 instance there was a collection between the hemispheres as well as over the right frontoparietal area. A subdural abscess was excised in a patient in whom a chronic subdural hematoma had been evacuated (Case 20). The excision of the subdural abscess which contained a lining similar to a subdural hematoma was done 22 days after the removal of the subdural hematoma through a left parietal osteoplastic craniotomy. In 1 instance, a combination of a subdural abscess and a subdural hematoma was found on the right side (Case 18). Paracolon bacillus was cultured. In 1 patient (Case 19), an associated left frontal intracerebral abscess was present.

In subdural abscess, the history of sinus disease and upper respiratory infection is common. Rapid development of signs and symptoms with coma in a week or 10 days associated with convulsions, particularly of the Jacksonian type, is frequent. In lesions of the left side an aphasia was also seen.

TABLE I.—SUMMARY OF 22 CASES OF CIVILIAN BRAIN ABSCESS

Case No. Patient	Age, yrs.	Sex	Focus of infection	Organism	Menin-gitis	Location of abscess	E.E.G.	Diagnostic procedure			Type of treatment				Result
								Ventricu-lography	Encephal-ography	Angio-graphy	Tap	Repeated taps and penicillin instill-ation	Drain-age	Exci-sion	
1 G. W.	41	M	?	Pleomorphic variable rod	Yes	Rt. parietal	Did not localize	Preoperative		Post-operative	x				Recovered
2 E. W.	47	M	Frontal sinus	Streptococcus hemolyticus	None	Lt. fronto-temporal subdural	Correct	Post-operative		Preoperative, positive	x				Recovered
3 R. H.	25	M	Traumatic	Gram positive cocci Staphy-loccus aureus	None	Rt. frontal lobe	Correct		Post-operative		x	x		x	Recovered
4 G. L.	29	M	Right mastoid	Streptococcus viridens	None	Right temporal	Correct				x	x			Recovered
5 J. G.	34	M	Blood borne	Culture negative	None	Lt. tempero-parietal	Correct		Preoperative		x	x			Recovered
6 W. M.	41	M	Brain tumor	Stap. haureus	None	Rt. parieto-temporal	Correct	Preoperative						x	Recovered
7 R. K.	30	M	Right mastoid	Nonhemolytic streptococci	None	Rt. temporal subdural	Correct	Preoperative	Preoperative and post-operative		x	x			Recovered
8 L. B.	22	M	Blood borne	Streptobacillus moniliformis	None	Rt. parieto-temporal	Correct	Post-operative			x	x			Recovered
9 D. R.	17	M	Frontal sinus		None	Lt. frontal	Correct							x	Recovered
10 S. S.	25	M	Traumatic	Not known	None	Lt. frontal extradural	Correct	Post-operative	Post-operative	Preoperative	x				Recovered
11 E. D.	28	F	Paradoxical	Microaerophilic Strep. hemoly-ticus	None	Rt. fronto-parietal	Correct				x	x			Died
12 F. F.	47	M	Lung abscess	None found	None	Rt. parietal	Correct		Preoperative		x				Recovered
13 E. I.	61	F	Blood-borne	Gram positive cocci strepto-cocci	None	Lt. frontal	Correct				x	x	x		Died
14 L. G.	25	M	?	Streptococcus nonhemolyti-cus	None	Lt. parieto-occipital	Correct		Post-operative		x	x			Recovered
15 F. G.	60	M	Brain tumor	Anoerobic streptococci	None	Rt. occipital	Incorrect	Preoperative			x	x		x	Recovered
16 C. K.	19	M	Rhinoplasty	Staph. aureus	None	Rt. frontal	Correct	Post-operative	Post-operative	Preoperative and post-	x	x		x	Died

15 F. G.	60	M	Brain tumor	Anaerobic streptococci	None	Rt. occipital	Incorrect	Preoperative								Recovered
16 C. K.	19	M	Rhinoplasty	Staph. aureus	None	Rt. frontal	Correct	Post-operative	Post-operative	Preoperative and post-operative	x	x		x	Died	
17 C. M.	40	M	Rt. frontal sinus	Hemolytic streptococci	None	Rt. fronto-parietal subdural	Correct		Post-operative		x				Recovered	
18 C. F.	42	M	Traumatic	Paracolon bacillus	None	Rt. frontal subdural	Correct		Post-operative		x	x	x		Recovered	
19 N. N.	23	M	?	Microaerophilic streptococcus	None	Rt. fronto-parietal interhem-ispheric	Did not localize				x				Recovered	
20 J. H.	52	M	?	Gram positive diplococci (urethra)	None	Lt. parietal subdural	Correct		Preoperative					x	Recovered	
21 H. M.	50	M	Traumatic	Anaerobic micrococcus	None	Rt. parieto-temporal			Post-operative		x	x			Recovered	
22 J. W.	63	M	?		None	Rt. temporal and many other foci of pus	Incorrect			Negative					Died	

In the management of subdural empyema 1 or more trephine openings are made for evacuation of the pus and penicillin instillation. The subdural area is washed out with a penicillin solution. In 1 instance a bone flap was turned and an interhemispheric collection was exposed.

The use of air studies or angiography is valuable to locate the lesion or re-evaluate the patient for further intervention, if his course has been unsatisfactory. Tube drainage of the subdural area has not been used in the last 5 cases. Systemic antibiotic therapy after sensitivity tests and closure of the wounds after drainage of pus and penicillin instillation have been therapeutically successful.

Epidural abscess. Epidural abscesses occurred in 2 instances in this group of patients. One of these was associated with frontal sinus disease and was reported previously, (3, 4). The patient in the present group developed an extensive osteomyelitis of the frontal bone following an injury to the eyes by metallic powder which caused an inflammation of the conjunctival lining (Case 10). In Figure 1, the extensive bilateral involvement of the bone can be seen. Upon opening the skull in the left frontal area, large quantities of pus escaped from an epidural collection. The dura was thickened on the left side to about 4 to 10 millimeters. Biopsy revealed chronic inflammatory disease of the dura. Because there was a marked shift of the ventricles suggesting a left parietal mass, as may be seen in Figure 1e, several areas were unsuccessfully tapped for an intraparenchymatous abscess. The shift of the ventricular system eventually disappeared after conservative management for 6 months.

Epidural abscess is a common accompaniment of osteomyelitis of the skull. In the instance described the possibility of an intracerebral abscess was also thought to be likely, however, none was found and we assumed the thickened dura was the cause of the shifted ventricular system of cavities (Fig. 1).

Intraparenchymatous abscess. In the present group, there were unusual and interesting

TABLE II.—SUMMARY OF 6 CASES OF SUBDURAL ABSCESS

Case No.	Age, yrs.	Sex	Cause	Site	Organism	Associated intracerebral abscess	Meningitis	Convulsive seizures—Preoperative—Jacksonian	Convulsive seizures—Preoperative—Generalized	Convulsive seizures—Postoperative—Jacksonian	Convulsive seizures—Postoperative—Generalized	Diagnostic procedure	Follow-up period, Mos.
2	47	M	Frontal sinus	Lt. fronto-temporal	Streptococcus hemolyticus	No	No	No	No	No	No	Angiogram shows rt. frontal	8
7	30	M	Rt. mastoid	Rt. temporal	Nonhemolytic streptococci	No	No	No	No	No	No	Displacement of pineal and supracallosal cistern to lt.	18
17	40	M	Frontal sinus	Rt. frontal	Hemolytic streptococci	No	No	No	No	No	No	Deformity of anterior horn to lat. ventricle	36
18	42	M	Traumatic	Rt. frontal	Paracolon bacillus	No	No	No	No	Yes	No	Shift of ventricles to left	10
19	23	M	?	Rt. fronto-parietal and interhemispheric	Microaerophilic streptococcus	Yes (lt. fronto-parietal)	No	Yes	No	Yes	No	Not done	26
20	52	M	Post-operative subdural hematoma	Lt. parietal	Gram positive diplococci	No	No	Yes	No	No	No	Marked shift to right of ventricles	48

findings in some patients with intracerebral abscess. In 1 patient (Case 1), meningitis existed with 2,250 cells with 85 per cent polymorphonuclears in the spinal fluid. An inbending of the right ventricle from above its frontal portion was noted by ventriculography. Some air also entered the cavity of the small abscess which drained into the ventricular cavity and contaminated the cerebrospinal fluid. A needle was inserted into this area and purulent matter was removed on 1 occasion only, and the cavity was instilled with penicillin. The patient made a satisfactory recovery and postoperative air studies showed a disappearance of the defect in the ventricles; the cavity of the abscess evidently became obliterated (Fig. 4). The emptying of this abscess into the ventricles undoubtedly caused the meningitic reaction which was recorded from the spinal fluid examination.

Two patients (Cases 5 and 14) were explored for a brain tumor. Needling of the area confirmed the presence of brain abscess. One was located in the left parietotemperofrontal junction and the other in the left parieto-occipital area (Fig. 2). The bone flap was replaced in each case and the abscess was aspirated, and penicillin was instilled on repeated occasions through a new trephine opening overlying the purulent collection.

Two abscesses in the group were caused by trauma, 1 was treated by excision, and the other treated by repeated drainage and penicillin instillation following the débridement of the improperly débrided wound (Fig. 5).

One of the patients who were treated by a trephine opening died several hours after the diagnosis was established by drainage of an abscess in the right parietal area. This patient had a paradoxical brain abscess.

Another interesting problem was presented by a patient infected with Streptobacillus moniliformis which is a common organism in the mouth of rodents. He was a medical student and may have been infected from a rabbit in the laboratory. He developed headaches, Jacksonian sensory fits in the left upper limb, and a pleocytosis, 175 cells, of the spinal fluid consisting mostly of lymphocytes. About 48 hours after entrance to the hospital, respiratory paralysis developed but artificial respirations followed by evacuation of an abscess (right parietotemporal) resulted in an eventual recovery. The organism was not sensitive to the usual antibiotics. Nevertheless, the patient (Case 8) was treated by repeated tap and penicillin instillation.

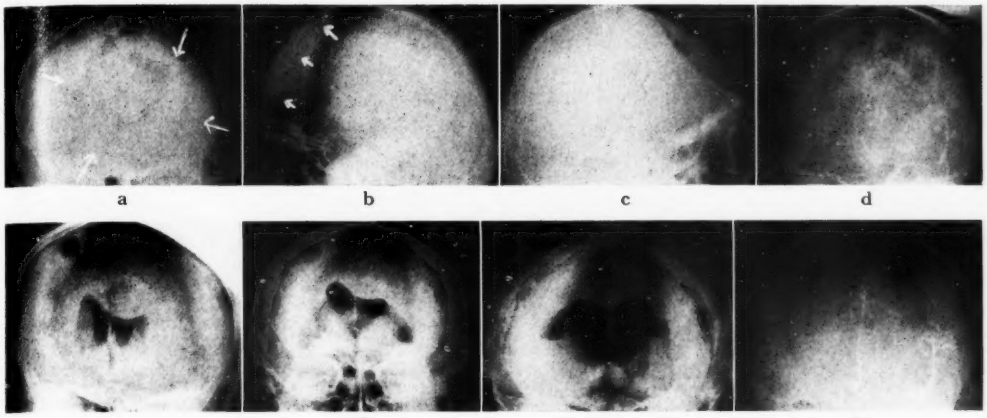


FIG. 1. S. S., Case 10, aged 25, had osteomyelitis of the skull. a, b, and c, Although both sides of the midline are involved, a large epidural collection of pus was found on the left side. Note the extensive destruction of bone and the extent of bone removal following craniectomy. d, Angiogram shows shift of the anterior cerebral to the right of the midline. e, After the evacuation of the epidural collection, a ventriculogram was performed. This suggested a parasagittal mass in the posterior parietal area. Tapping this region for possible intracerebral brain abscess revealed no lesion. However, the dura on the left side of the midline was thick, in places 8 to 10 millimeters. f, A month and a half later, another ventriculogram showed the shift but of less degree. g and h, Five and a half months later, another ventriculogram and angiogram appear normal. We have assumed that the persistent ventricular shift was due to not only the epidural collection of pus but also the very much thickened dural lining and cerebritis.

In 4 instances a mass was excised. In 2 instances earlier, repeated drainage and penicillin instillation had failed. In Case 15, a diagnosis of a left parieto-occipital mass was made by ventriculography, and purulent matter was obtained from the left occipital lobe. This patient did not improve satisfactorily. Three months later he was readmitted, and a mass was excised consisting of a metastatic adenocarcinoma with purulent collections. That tumor tissue was present in the wall of the abscess was suggested earlier by the microscopic study of some of the material removed from the abscess cavity. One patient (Case 16) was infected with an organism that did not respond to any of the available antibiotics and, after many attempts including 2 excisions for recurrent brain abscess, the abscess was treated by exteriorization. While being treated by this method a sudden hemorrhage from a branch of the middle cerebral artery caused death. Initially, the patient had rhinoplasty, and 10 days after operation was readmitted because of bleeding from the nose, frontal headaches, a swollen left eye, and fever. Soon a mass appeared in the right frontoparietal area with roentgen evidence of destruction of bone immediately underneath the area of swelling (Pott's puffy tumor). A cavernous sinus thrombosis was suspected and eventually an osteomyelitis and brain abscess developed in the right frontoparietal area. Another example of excision was in the patient (Case 6) who faired poorly after operation for removal of brain tumor although the wound was well healed externally. Re-exploration 4 weeks later revealed an abscess which was excised. The wound was washed with a penicillin solution and closed without drainage; it healed satisfactorily.

PRINCIPLES IN THE MANAGEMENT OF INTRACRANIAL PURULENT COLLECTIONS

The first important consideration involves a diagnosis of the lesion. Clinical information may lead to the diagnosis of intracranial suppuration in patients with foreign bodies

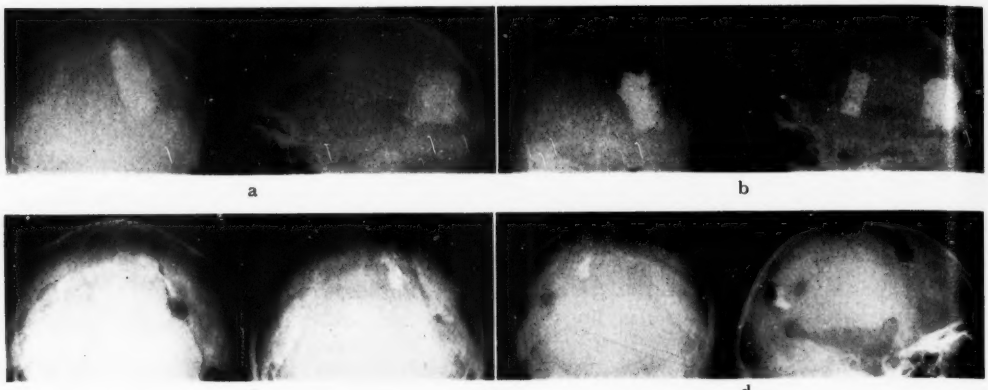
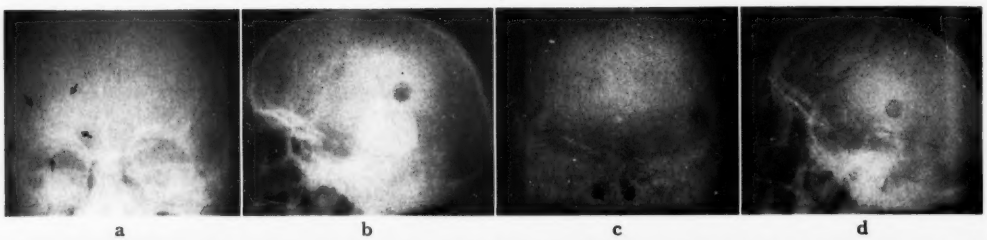


FIG. 2.



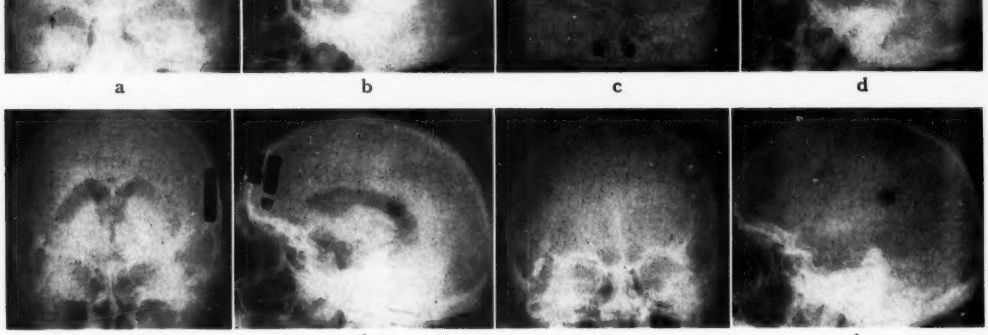
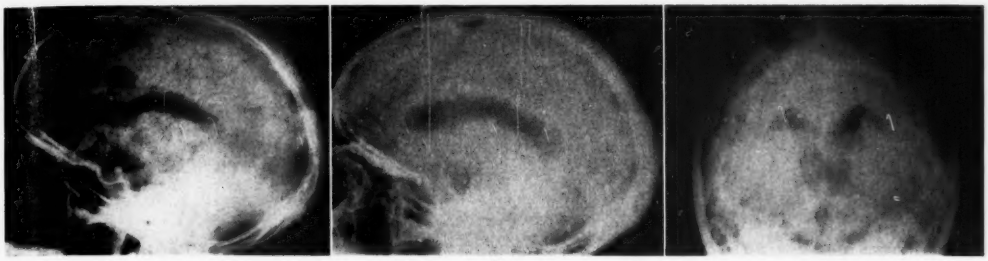


FIG. 3.

FIG. 2. L. G., Case 14, age 25, had evidence of a mass lesion in the left parietal area. A left carotid angiogram showed displacement of the anterior cerebral artery to the right and elevation of the middle cerebral artery. A bone flap was turned in the left parietotemporal region. The brain was soft and fluctuant in the posterior parietal area. A blunt needle revealed pus containing nonhemolytic streptococci. Three cubic centimeters of thorotrast was injected after washing out the abscess with penicillin solution. The bone flap was replaced, and the wound was closed and new burr hole was made immediately overlying the abscess. Thereafter, the abscess was repeatedly tapped and penicillin solution was instilled. It was possible to note the decreasing size of the abscess cavity on repeated studies, a, b, c, and d. X-ray films in d show a bolus of scar tissue impregnated with thorotrast 2 years after the evacuation of the pus. This patient has had 2 epileptic fits in a 4½ year period.

FIG. 3. G. L., Case 4, age 29, developed a right temporal brain abscess due to an ear infection. A right mastoidectomy was done on December 27, 1950 and on January 17, 1951 a right temporal abscess was tapped. After instillation of penicillin and 3 cubic centimeters of thorotrast, the patient was not tapped until 5 days later. Pre-tap roentgen studies 11 days later are shown in a and b, and studies after evacuation of the pus and instillation of penicillin are shown in c and d. This patient was treated by 6 attempts of drainage of pus over a period of 29 days, the last being unsuccessful. e and f, Air encephalograms reveal slight enlargement of the right ventricle but no displacement was obtained 5 months afterward. g and h, The survey roentgen studies were obtained 5½ years later and showed the bolus of scar impregnated with thorotrast.



a b c

FIG. 4. G. W., Case 1, age 41, came into the hospital with severe headaches, and a temperature of 102 for 10 days. Spinal puncture showed a cloudy fluid containing 2,825 white blood cells with 94 per cent polymorphonuclears and 6 per cent lymphocytes. On penicillin, terramycin, and sulfadiazine the spinal fluid count dropped to 295 white blood cells with 68 per cent polymorphonuclears and 32 per cent lymphocytes. a, Ten days after entrance into the hospital a ventriculogram showed a mass compressing the frontal portion of the right ventricle. Also note the air in the cavity. Through a frontoparietal opening purulent matter was obtained. b and c, Two weeks afterward, other ventriculograms showed slight dilatation of the right lateral ventricle, but the compression of its frontal area had completely disappeared. He recovered and there has been no sequelae for 26 months.

within the skull, osteomyelitis of the skull, otitis media, sinusitis, and recurrent bouts of meningitis. Neurologic signs and symptoms may localize the position of the collection. The spinal fluid examination may reveal an increase in cells, presence of organisms; usually the cell count shows a preponderance of polymorphonuclears but lymphocytic preponderance may also be seen in some instances. The protein of the spinal fluid may be increased, in some instances, to such a degree as to suggest the possibility of block. The sugar is not decreased in brain abscess and normal levels of glucose may be found in the cerebrospinal fluid. Chlorides usually are not decreased. If a focus of infection is present, such as a sinus infection or mastoiditis, excision of the focus usually is necessary.

Electroencephalography, ventriculography, and encephalography or angiography usually are necessary in confirming the clinical impression as well as in localizing the abscess.

In the surgical management of intracranial suppuration the following steps are valuable: subdural and epidural abscesses do well on burr hole drainage and penicillin instillation; if there is an associated osteomyelitis of the skull, as much of the diseased bone as is grossly recognizable at operation should be excised. After complete drainage of the collection tight closure is used. Tube drainage has not been employed in the past 6 patients with subdural and epidural collections. Multiple trephine openings are used for evacuation of subdural pus. If an interhemispheric collection is suspected, tapping through a trephine opening may enter the collection. Both sides should be tapped because of the presence of the falx cerebri. In our cases, the interhemispheric region was inspected through a bone flap. This may have to be done in some cases, but burr hole tap is much simpler if adequate.

With intraparenchymatous collections, tapping of the abscess is the first procedure and is done through an opening over the collection of pus. The contents are gently aspirated; the thickness of the abscess wall is estimated as the brain cannula penetrates; the cavity is irrigated with a penicillin solution and 2 to 4 cubic centimeters of thorotrast are instilled into the cavity after the irrigation. This material impregnates the wall of the abscess and can be subsequently noted in the roentgen studies to point out the changes in the outline of the cavity and to help decide whether a second, third, or more aspirations are indicated. In 2 patients a single tap and penicillin instillation resulted in a cure. Repeated roentgen studies may show that the cavity has collapsed and

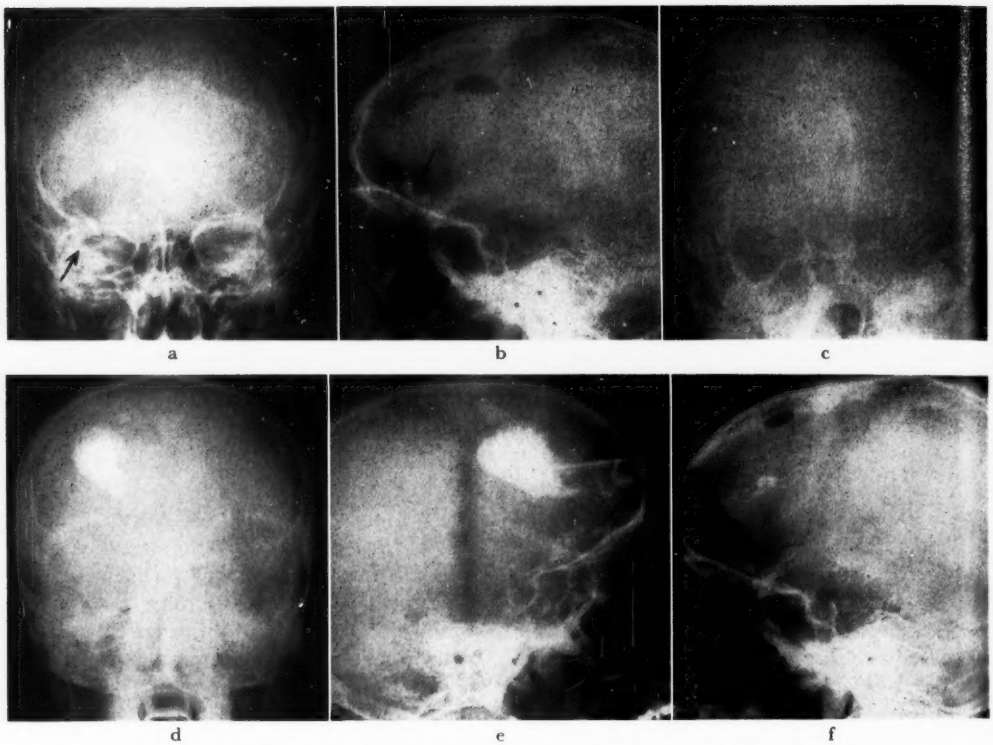


FIG. 5. R. H., Case 3, age 25, sustained an open, depressed skull fracture of the right frontal area and was transferred to our service about 45 days later. There was a history of cerebrospinal fluid rhinorrhea and a lethargic state with signs of increased intracranial pressure. The wound in the right frontal area in the region of the brow had never healed. There was some escape of purulent matter from time to time. a and b, Roentgenograms of the skull showed several free fragments of bone and air in the ventricular cavity. Arrows point to the fragments of bone. An angiogram revealed a mass lesion in the right frontal area presumably an intracerebral abscess or a subdural collection. The wound was revised, the fragments of bone were removed, an epidural collection of purulent matter was evacuated, and on palpation with a blunt needle a cavity was entered in the right frontal lobe from which about 25 cubic centimeters of yellow pus escaped. d and e, Penicillin and 3 cubic centimeters of thorotrast were injected. f, In order to evacuate the purulent collection in the right frontal lobe a frontal burr hole was made. On 2 occasions the purulent matter was removed by tapping the abscess through this opening and penicillin was instilled. Complete healing took place. This patient is to have a cranioplasty for repair of the skull defect in about 12 months, after the healing of the wounds. This was a traumatic abscess necessitating redébridement of an improperly débrided wound as well as repeated tap and penicillin instillation of the frontal lobe abscess.

the wall contracted as demonstrated by the thorotrast (Fig. 3). If the patient's condition improves and it appears likely that a cure has been obtained, check air or angiographic studies are employed to confirm the clinical result. The possibility that there are other collections of pus in the cranial cavity should be kept in mind since occasionally multiple abscesses may occur which respond to surgical treatment.

If a patient is not improving satisfactorily then exploration and excision through a bone flap are indicated, after diagnostic studies for accurate localization. Excision was carried out in 4 of the 22 instances in the group presently reported. An acute fulmin-t-

ing cerebritis may be attacked in this manner and the pathologic tissue excised *in toto*. However, in many instances, except when there are multiple abscesses, the use of antibiotics tends to localize the lesion and usually overcomes the cerebritis seen so frequently before penicillin and sulfonamide therapy.

The traumatic type of intracranial suppuration should be treated by total excision particularly when inadequate débridement and foreign bodies are noted. In civilian type of traumatic abscesses, occasionally, drainage by repeated tapping may be successful (Fig. 5). In the patient in Figure 5 the wound was completely redébrided and the frontal lobe abscess in the substance of the right frontal lobe was treated by repeated aspiration and penicillin instillation.

Antibacterial therapy is employed initially in massive doses to cover a wide spectrum of organisms, and if the organism is identified and its sensitivity response is noted then the most favorable antibiotic is used. Otherwise, the use of wide spectrum drugs is continued.

RESULTS

The mortality from brain abscesses, including all cases seen on a neurosurgical service, is around 20 per cent. In the 22 cases presently reported, the mortality was 18.1 per cent. This includes the death of 1 patient whose purulent collection was not removed by operation. When one compares the first group (1944 to 1950, 5 deaths in 23) with the group since 1950 (4 deaths in 22) the mortality rates are approximately the same. With the present day management, when a purulent collection has been identified there is an 80 per cent likelihood of a successful outcome by surgical removal.

Among the 9 deaths in the entire series, 3 were due to multiple metastatic abscesses. One death occurred in a patient who was infected with an organism insensitive to the available drugs. One death was caused by a paradoxical abscess and likely invasion of other portions of the nervous system. One death occurred 6 hours after drainage of 60 cubic centimeters of yellow pus and 1 after the excision of a left cerebellar abscess. One death was of a patient who had been in a moribund state throughout 3 hospital days.

Other sequelae of brain abscess include epilepsy, mental disorders, and focal abnormalities such as aphasia, homonymous hemianopsia, hemiplegia or hemiparesis, and sensory abnormalities. Epilepsy is the most frequent of the complications, and among those patients with a subdural abscess the likelihood of postoperative convulsive disorder is 60 plus per cent. Six of our patients with subdural abscess had preoperative or postoperative epileptic fits, and 5 out of 10 have had postoperative fits, controlled fairly satisfactorily with anticonvulsant drugs. Among those patients with intraparenchymatous abscess, epilepsy has been seen with equal frequency with excision as well as with repeated tapping and drainage of the abscess. The epileptic attacks may be infrequent. One of our patients has had 2 spells in 3 years. Another patient had his first attack 4 years after removal of the abscess and has had 1 attack since. Fifty-five per cent of the surviving patients with intraparenchymatous abscess have had 1 or more convulsions.

In 1 patient with a parietotemporal abscess, a persistent homonymous hemianopsia has been present for 3 years. There was also a left sixth nerve paralysis in this case. In most instances a hemiplegia or hemiparesis completely disappeared after the removal of the abscess. In 1 case associated with aphasia and right hemiplegia, a mild speech disturbance continued for many years.

SUMMARY AND CONCLUSIONS

1. After the diagnosis and localization of an intracranial suppurative lesion have been established, burr hole evacuation of the purulent collection and instillation of penicillin are employed. In epidural and subdural collections this method may suffice. In intraparenchymatous collections, repeated taps and penicillin instillation may result in complete collapse of the purulent cavity. This may be noted in survey roentgen studies by the position of the thorotrast injected into

the abscess. The abscess wall stained with thorotrast eventually contracts into a bolus of scar with complete obliteration of the cavity.

2. Among the patients who do not improve satisfactorily, a second step employs an excision of the mass through an appropriate bone flap and after supplementary diagnostic procedures. The possibility that there may be a second abscess in the vicinity of the first should also be kept in mind in such cases. This was true in 2 patients of the entire series in our group.

3. Multiple abscesses still pose a difficult therapeutic problem in that they represent a majority of the failures in surgical management. At least 3 of the 9 deaths in the entire group of 45 patients and 1 of the deaths in the last 22 patients were caused by multiple abscesses.

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OSSEOUS PHLEBOGRAPHY

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KNOWLEDGE OF THE ANATOMIC and physiologic aspects of the osseous circulation is limited because of the inherent difficulties encountered in investigating it. However, excellent work has been done by Doan on the study of the circulation through the long bones of pigeons, dogs, cats, rabbits, and rats; by Drinker; and recently by Truetta in his exhaustive analysis of the circulation to the head and neck of the femur. These 3 investigators have provided most of the present information on this subject. The following description of the anatomy of the circulation of bones is based mainly upon their observations supplemented by our own observations of the circulation through the veins as demonstrated by osseous phlebography.

Arterial blood enters the long bone through three sources. The most important source is the nutrient artery, which, in some bones, may be 2 or more in number. The nutrient artery runs a tortuous course before entering the medullary canal, generally obliquely through the cortex of the shaft. After entering the medullary canal it divides and sends one or more branches up and down the bone toward the metaphyses at either end (Fig. 1). Along its course in the shaft the nutrient artery gives off small branches at intervals, passing to the inner surface of the cancellous bone through horizontal canals which are known as Volkmann's canals. These vessels anastomose extensively with other small arterioles which enter the bone from the periosteum and with an extensive venous network comprised of small venules. The branches from the central arteries become more numerous at the periphery of the bone. According to Truetta, there is an extensive anastomosis between these nutrient arteries and the metaphyseal circulation occurring in the spongy bone. This anastomosis does not occur in the proximal end of the femur, as Truetta found no evidence to support the contention that the nutrient artery contributes any circulation to the head and neck of the femur. With increasing age, the nutrient artery becomes smaller because of the decreased blood supply to the diaphysis as a result of replacement of the red marrow with less vascular fatty marrow.

Numerous small arteries enter the outer surface of the compact bone from the periosteum through Volkmann's canals and pass into the haversian system. These vessels, for the most part, supply the outer compact layer and enter into extensive anastomoses with the branches of the nutrient and metaphyseal arteries and the abundant venous circulation. The blood supply in the haversian system is oriented in a vertical direction with the vasculature being comprised mainly of small arterial capillaries and considerably larger venous capillaries.

Large and small branches from arteries of muscles and tendons enter the metaphyseal and epiphyseal portions of the bone. These vessels in the epiphysis and metaphysis maintain separate patterns and widespread anastomoses. In the growing bone the epiphyseal cartilage, or growth plate, is an effective barrier to the admixture of blood from the epiphysis and metaphysis, but with the cessation of growth and the formation of a scar adjacent to the cartilage, the vessels may cross the scar and set up additional anastomoses. As mentioned be-

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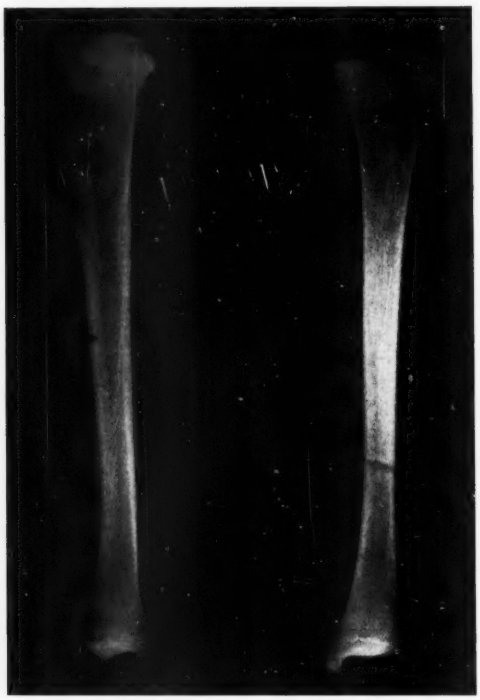


FIG. 1. The nutrient artery of a tibia has been injected with radiopaque material. The nutrient artery divides sending medullary branches up and down the medullary canal. The arteries are much narrower and of a more uniform caliber than the veins. Compare with Figure 2.

fore, the metaphyseal vessels generally communicate with the periosteal and nutrient arteries.

In the hematopoietic marrow of spongy bone the arterioles divide extensively and enter the large venous sinusoids. With the transformation of red marrow to yellow fatty marrow, the sinusoids are replaced by capillaries that are similar in size and structure to capillaries elsewhere in the body. The venous sinusoids are numerous and spacious vascular caverns, several times the size of capillaries but with walls of the same thickness as those of the capillaries; the sinusoids are present in clumps in the red marrow and receive blood from many directions and form the principal functioning vascular bed for actively circulating blood. The capillaries are widely distributed in fatty marrow and contain most of the blood present in compact bone.

The blood from the capillaries and venous sinusoids converge to enter the venules which flow into the larger venous trunks. All branches of the venous system are distinguished from the corresponding arteries by their larger lumen, more numerous branches, and much greater capacity. They are thin-walled vessels that do not contract when their wall is cut but remain widely patent. The veins have a more irregular course and may spiral around their companion artery. They do not have valves.

The course of the veins is roughly parallel to that of the corresponding arteries. The veins draining the tubular bones may be divided into 3 groups. A large vein (or veins) traverses the center of the medullary cavity carrying blood from the ends and cortex of the bone toward the nutrient foramen where it unites with the corresponding vessel (or vessels) from the other end of the bone and emerges from the nutrient foramen to pass into the soft tissues.

In the metaphyseal and epiphyseal regions and in spongy bone in general, the numerous venules frequently drain directly into large, thin-walled veins which emerge from the bone in the region of the attachment of muscles and tendons. These large veins provide the principal drainage pathways for opaque medium that has been injected into the cancellous portion of bones.

The venules of compact bone drain outward to the periosteum or centrally to enter the medullary vein through narrow vessels.

FUNCTIONAL ASPECTS OF BONE CIRCULATION

All attempts to follow roentgenographically the arterial and venous circulation through bone after injection of a major afferent artery with opaque liquids have been unsuccessful. In an extensive series of arteriograms done on humans and dogs, using large doses of contrast material, Lamas, Amado, and Da Costa (14, 15) were never able to demonstrate any of the arterial supply to bone, nor were they able to demon-

FIG. 2.

FIG. 3.

FIG. 2. Injections into the proximal ends of both tibias demonstrating the numerous small vessels in the ends of the bones and the metaphyseal and central medullary veins draining the bones. The lower portion of the left leg has been amputated.

FIG. 3. Injections into the medial malleoli of both tibias. The superficial and deep veins of the lower leg and the femoral and saphenous veins of the proximal portion of the leg along with communicating vessels are seen. The central medullary vein in the tibia can be seen extending about one-third of the way up the shaft.

FIG. 4. A destructive lesion of the head and neck of the left humerus which was revealed to be a simple cyst upon exploration. The central medullary vein has been injected directly.

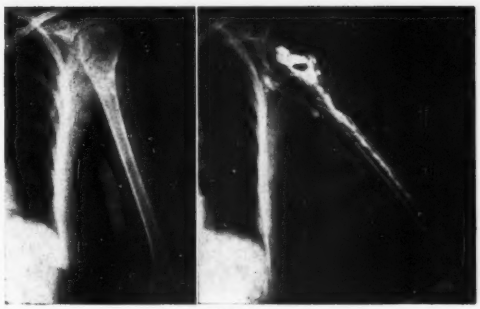


FIG. 4.

strate the intrinsic circulation of bone. They could demonstrate very minute vessels in soft tissues but none in bone. They injected indigo carmine into the external iliac artery of dogs and observed the time required for the appearance of the dye in the skin, in a superficial wound of the paw, and in bone trepanated or sawed. The indigo carmine appeared in the wound within 4 seconds, in the skin within 7 seconds, but not in the bone marrow until a minute or longer had elapsed. The dye was never seen in the compact substance of bone. The color was vivid in the soft tissues and less intense in the bone marrow. Three and one-half minutes later the bone marrow was no longer stained, whereas the skin remained stained for over 10 minutes. These investigators concluded that the circulation in bone was slow and that substances introduced into the arterial circulation arrived there in small quantities and became greatly diluted. Experiments conducted by Jergesen, in which contrast substances were injected directly into bone and their clearance rate determined, would indicate that venous drainage from bones, and consequently arterial circulation to bones, is not slow. Thus, it would appear that the dilution provided by the large pools of blood within the bone is the main factor. Petrakis (18) injected radioiodide into the bone marrow and muscles and noted that their clearance rate was similar, indicating that the rate of circulation through bone is approximately the same as through resting muscle.

Lamas and his associates state that the blood pressure in bone is low because of the

FIG. 5.

FIG. 6.

FIG. 5. Bilateral simultaneous injections into the heads of both femora. The head of the right femur has become necrotic following a femoral neck fracture. The roentgenogram to the right was obtained about 45 minutes after the injection had been completed. The contrast material has drained from the head of the left femur but still remains in good concentration in the femoral head and joint space of the right hip.

FIG. 6. Femora of a young girl who has neurofibromatosis. The injection on the right side has been made into the epiphysis and on the left side into the metaphysis. There is no circulation across the epiphyseal cartilage. Compare this with the adults in Figures 2, 3, and 4.

tortuosity of the vessels leading to bone, the large number of branches that are formed, the small caliber of the lumen, and the rigid walls of bone surrounding the vessels and preventing expansion. However, Petrakis (17) measured the vascular pressures in normal human marrow and in the marrow of patients with leukemia and noted a pulsating pressure above the venous pressure. He observed that the marrow behaves as a semiclosed cavity, the pressure within which is determined by the quantity and pressure of the blood entering and leaving.

The ease with which large quantities of various solutions could be rapidly introduced into the bone marrow suggested to previous investigators that this might provide a means of demonstrating the venous circulation of bone. Numerous articles have appeared in the European literature describing this technique and its practical applications.

Various types of needles have been developed with which to inject the contrast material into the bone. The needle must be sturdy in order to withstand the pressure required to insert it into the bone and must have a wide lumen. Some investigators recommend a local anesthetic, but the injection of the contrast material has sometimes proved to be extremely painful as the result of the great pressure exerted on the rigid bony

structures. We have used a short-acting general anesthetic, for the pain rapidly subsides after the completion of the injection. The pain of injection is greater in those cases in which the injected liquid does not enter the draining veins because of impaired venous drainage.

A No. 15 bone marrow needle with a trephine and stylet has proved adequate for those bones close to the surface; a longer needle is necessary for bones more deeply situated. The needle may be inserted with a rotatory movement with a serrated trocar, or be introduced by sharp blows with a mallet.

Blood is aspirated from the bone marrow and then 10 to 20 cubic centimeters of an aqueous contrast medium are injected rapidly. Because hypaque (50 per cent) appears to be less toxic to tissues after local injection than other contrast media in use at present, it seems to be the most suitable substance.

The first roentgenogram usually is exposed immediately after the completion of the injection. Additional roentgenograms are obtained at varying intervals, depending upon the purpose of the examination.

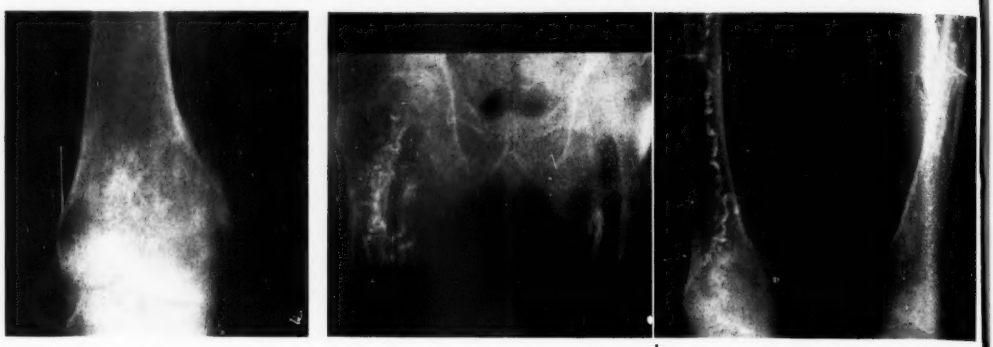
COURSE OF THE CONTRAST MATERIAL INJECTED INTO CANCELLOUS BONE

For a distance of a few millimeters to a few centimeters surrounding the needle point, a small amount of contrast material probably passes into the connective tissue stroma. This presents a more or less homogeneous, poorly delimited shadow on the roentgenogram, the shadow persisting for a long period of time after the major portion of contrast material has disappeared from the bone. Most of the contrast material passes rapidly into the venous sinusoids which radiate from the point of injection and drain into the small venules. These vessels appear on the roentgenogram as a network of interlacing channels and vary in size depending upon the vascularity of the bone. The sinusoids and venules at various levels of the bone are superimposed upon each other so that the course of individual vessels cannot be followed. The venules converge

a b

FIG. 7. a and b, Injection of contrast material into the distal end of the tibia which had been fractured 4 months previously. The venous circulation has been reconstituted, but there is still evidence of venous stasis as demonstrated on the film obtained 3 hours later.

and form larger trunks which emerge from the bone. If the injection has been made into the end of a long bone, most of the injected solution leaves the bone through the large veins in the metaphyseal region. Other large veins also pass through the cortex of the diaphysis (Fig. 2). The medullary vein can be seen usually extending along the shaft of the bone for varying distances. If the injection is made into the distal end of the tibia, the medullary vein can be seen usually in the lower third or lower half of the bone. Presumably, this vein extends up to the level of the nutrient foramen where it joins the medullary vein carrying unopacified blood from the proximal end of the bone and forming the nutrient vein which leaves the bone through the nutrient foramen. The medullary vein during its course in the diaphysis receives unopacified blood from its tributaries so that the contrast material becomes



a b

FIG. 8. a, Plain roentgenogram of the distal end of the right femur showed a destructive process with central calcification and a large soft tissue mass due to an enchondroma surrounded by a fibrosarcoma. b, Osseous phlebogram of the femora of the same patient. An enchondroma was also present in the region of the greater tuberosity of the right femur. The medullary vein and metaphyseal veins are encroached on by bone tumors.

diluted as it approaches the nutrient foramen. For this reason it becomes less visible as it traverses the shaft, and the nutrient vein may not be demonstrated (Fig. 3).

The medullary vein is a tortuous, irregular tube with a wide lumen and in some instances presents the appearance of a plexus of small interlacing communicating vessels (Fig. 4). Although it lies for the most part near the center of the medullary canal, it has an undulatory course and at times approaches closely the endosteal surface of the cortex. Occasionally, after an injection into the spongy bone of an extremity, the entire course of central vein will be seen.

The venous drainage from the proximal end of the femur appears to differ somewhat from that of the tibia. After injections into the head of the femur, the central vein is seldom seen. This is presumably because of the abundant venous drainage from the bone n the region of the intertrochanteric line and just proximal to it (Fig. 5). Truetta, in discussing the circulation to the head and neck of the femur, stated that he found no evidence for nutrient artery extending its area of supply to the metaphyseal region.

COURSE OF THE CONTRAST MATERIAL INJECTED DIRECTLY INTO THE MEDULLARY VEIN

If the needle is inserted through the compact layer of the shaft of a long bone and into the medullary canal, the injected material passes directly into the lumen of the medullary vein. It is surprising that on none of our roentgenograms is there any evidence of extravasation of the injected substance into the connective tissue, even though the needle has been inserted blindly. Generally the entire central vein and, to a varying extent, the small venous channels at the ends of the bone are rendered opaque. The veins passing through the nutrient foramina and emerging from the metaphyseal and epiphyseal regions are usually well seen (Fig. 4).

There is no venous communication across the growth plate or epiphyseal cartilage between the epiphysis and metaphysis of growing bones (Fig. 6). However, once growth ceases and the cartilaginous plate becomes a lamellar bone plate, the small venous channels between the epiphysis and metaphysis may communicate through an extensive network of anastomoses. The contrast material injected to one side or the other of the scar of the growth plate usually passes across it without interruption (Figs. 2, 3, and 4). We have had a few cases, however, in which the material injected into the head of the femur of adults passed readily to the growth plate but did not cross it.

The technique of osseous phlebography may be used: (1) to demonstrate the normal venous circulation of bone, (2) as an addi-

FIG. 9.

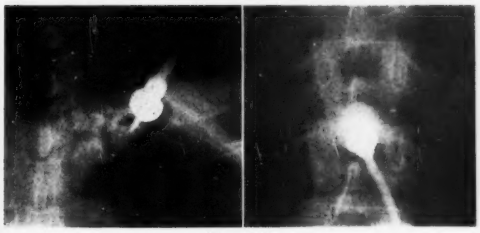


FIG. 10.

FIG. 9. Osteogenic sarcoma of the shaft of the left femur. The opaque medium enters the venous circulation of the neoplasm.

FIG. 10. Injections into the medial end of the left clavicle and the spinous process of the third lumbar vertebra in a patient with myelogenous leukemia. The opaque medium does not enter the osseous venous system.

tional aid in the diagnosis of diseases of bone as a result of alterations in its blood supply, (3) to study the rate of disappearance of contrast material as an indication of the rate of blood flow through normal and diseased bone, and (4) to visualize the deep venous channels draining the bones.

Menegaux, Leger, and Detrie, by injecting the distal fragment of fractured long bones, have studied the alterations that occur in the venous circulation in the acute phase and during healing. They have observed an interruption of the central medullary canal and a stasis distal to the fracture line. The injected opaque material spread for some distance beyond the needle point but did not enter the larger venous channels or drain from the bone. This was observed in all fractures studied and persisted until the healing of the fracture had been well established. One of us (F. J.) encountered a complete fracture of the tibia with little displacement in which the central medullary vein was intact and passed uninterruptedly across the fracture line. During the course of healing the venous circulation is slowly reconstituted, but as long as 4 months after the occurrence of the fracture there still may be evidence of delayed venous drainage (Figs. 7a and b). These results suggest a possible application of this method in the determination of the extent of healing of fractures and may add some information as to the cause of the failure of some fractures to heal by bony union.

We have encountered two types of alteration of the venous system of bone produced by malignant tumors. Figures 8a and b show an osseous phlebogram of a femur in which there was a large fibrosarcoma producing extensive destruction of the distal end of the bone. The lesion contained some calcification and extended into the soft tissues surrounding the bone. The distal part of the medullary vein was obstructed by the neoplastic mass, and the contrast material passing up the vein in a retrograde direction did not enter the tumor. An enchondroma which was present in the proximal end of the shaft of the same femur also prevented the retro-

FIG. 11. Bilateral injections into the medial aspects of both calcanei. There has been a fracture of the middle of the shafts of the right tibia and fibula with malunion at the fracture sites. An obstruction of all of the deep veins of the right leg has occurred in the region of the fracture.

grade flow in a proximal direction. This method of examination may be of some value in determining the gross extent of neoplasms in those cases in which the full extent of the lesion cannot be determined by other means; it may also provide evidence of extension of the tumor into the central vein. Another malignant tumor, diagnosed as an osteogenic sarcoma of the midshaft of the left femur, presented an entirely different pattern. The contrast material injected into the lateral condyle of the femur passed up a markedly enlarged central medullary vein and entered large venous lakes within the intraosseous portion of the tumor. It then passed laterally through the destroyed cortex of the shaft in numerous parallel veins which emptied into a large vascular puddle in the soft tissues. The increased size of the medullary vein suggested that the lesion was vascular and that its venous drainage was increased (Fig. 9).

An osseous phlebogram was done on an adult who had a large destructive lesion of the head and neck of the left humerus which was subsequently explored and found to be a simple cyst. The needle was inserted into the shaft of the bone above the level of the olecranon fossa. The contrast medium entered the central vein and flowed to the lower border of the lesion; some passed through the nutrient foramen and through other smaller branches to the cephalic vein. The caliber of the central vein just distal to

FIG. 12. Injection into the superior ramus of the left pubis.

FIG. 13. Injection into superior ramus of left pubis in elderly patient. Draining veins are dilated and tortuous.

FIG. 14.

FIG. 14. Injection into the superior ramus of the left pubis. The entire pelvis is extensively involved with Paget's disease. The draining veins are large and tortuous as a result of the increased circulation through the bones.

FIG. 15. Bilateral injection into the superior rami of the pubes. The patient had recurrent carcinoma of the bladder and carcinoma of the prostate with extensive metastases to the pelvis. There has been extravasation from the bone on the left side. The pelvic veins on the right side are displaced laterally and compressed by the pelvic mass.

FIG. 15.

the cyst was markedly dilated, with the dilatation gradually diminishing peripherally. The dilated central vein appeared to fill the entire medullary canal (Fig. 4). The most likely explanation for the increased venous drainage through the proximal central vein would appear to be that it was the result of the destruction and obliteration of the numerous large venous channels in the epiphysis and metaphysis which normally pass from the bone in the region of the muscular and ligamentous attachments. The only available venous drainage was through the central vein and then through the nutrient vein and the other efferent branches.

The rate of disappearance of a substance from a tissue into which it has been injected provides an indication of the extent of circulation present. The clearance time of a contrast material injected into the head of the femur has been investigated by Jergesen and has been published. When the circulation to the head of the femur has been impaired, such as in avascular necrosis following fracture of the neck or in some cases of traumatic arthritis, the contrast material injected into the head may disseminate widely within the bone and frequently it extravasates into the joint space, but none, or very little of it, passes into the efferent veins that drain the bone. Ordinarily an opaque medium injected into the head of the femur disappears from the efferent veins within 5 minutes and

FIG. 16. Injection into the left anterior superior iliac spine. There are extensive destructive lesions due to multiple myeloma.

FIG. 17.

FIG. 17. A young male with extreme edema of the entire left arm. A calcified mass was visible anterior to the humerus which upon biopsy was proved to be due to myositis ossificans. The injection was made into the lower end of the radius and outlined the cephalic vein which was obstructed at the level of the calcified mass. Collateral circulation is visible.

FIG. 18. Injection into the spinous process of the first lumbar vertebra demonstrating the paravertebral venous plexus, ascending lumbar veins, and the azygos vein. A large amount of fluid was present in the abdomen and chest reducing the contrast of the opaque medium.

FIG. 19. Injection into the superior ramus of the pubis in a patient with osteitis pubis. The veins draining the pubis are obstructed producing stasis and huge dilated veins within the pubis and immediately adjacent to it.

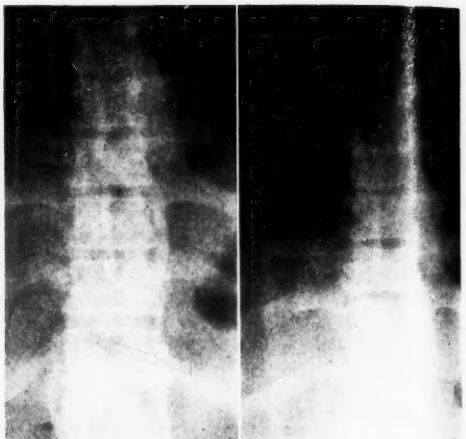


FIG. 18.

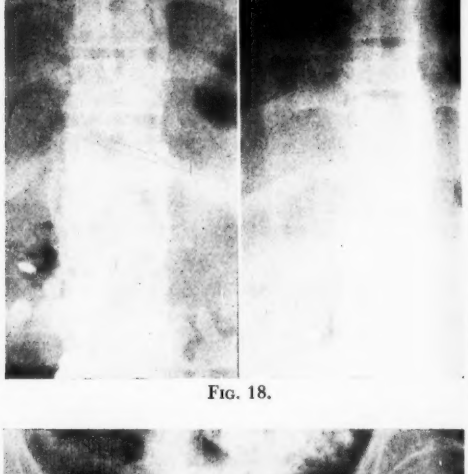


FIG. 19.

from the medullary cavity within 15 minutes. When injected into a femoral head with compromised circulation, it may continue to be visible on serial roentgenograms for several hours after the injection (Fig. 5).

We have also encountered delayed clearance from bone in several patients who had myelogenous leukemia. In 3 patients in whom the injection was made into the marrow of the body of the sternum, the contrast material spread rather homogeneously within the bone and none was observed to drain into the internal mammary veins. In all other patients receiving sternal injections the internal mammary veins filled and the bone cleared promptly. In 1 patient with myelogenous leukemia injections were made into the medial end of the left clavicle and the spinous process of the third lumbar vertebra. In each instance the contrast material

spread within the bone but did not pass into the draining venous system (Fig. 10). The cause for this delayed clearance is not known, but it is possible that the hyperplastic marrow in some manner prevented the injected liquid from entering the venous sinusoids. The number of cases examined is not sufficient for any conclusions to be made.

Judging from the articles that have appeared in the literature, osseous phlebography has been used mainly as a means of demonstrating the deep and superficial veins of the lower extremity.

Injections into the medial and lateral surfaces of the calcaneous, the medial malleolus of the tibia, or the lateral malleolus of the fibula demonstrate the deep and superficial venous circulation of the leg. Roentgenograms obtained after the rapid injection of 15 to 20 cubic centimeters of the opaque medium generally demonstrate the superficial veins, the posterior tibial, peroneal, anterior tibial, and communicating veins. The patient should be tilted to a semivertical position to prevent layering between the blood and the injected liquid. By this technique the deep veins and the superficial veins of the leg fill almost simultaneously. The filling of the deep veins is not dependent upon the filling of the superficial veins first and then passage through the communicating veins, as happens with the usual methods of phlebography of the lower extremity. It is thus a more physiologic approach to the study of the venous circulation. Films of the thigh obtained a few seconds after the completion of the injection will show the femoral, long saphenous, and communicating veins (Fig. 3).

Venography of the lower extremity, as performed in the past by Crockett, Dow (5, 6), Felder (8, 9), Greitz, Gryspeerdt, and many others, has proved to be useful in the diagnosis of obstruction or incompetence of the deep veins, of incompetence of communicating veins, and of varicosities and incompetence of the superficial veins of the leg (Fig. 11). The diagnostic criteria are the same if the injection has been made into the bone as it is for other techniques, and will be discussed in detail in another publication. The injection into bone offers the following advantages: (1) it is a more physiologic approach; (2) it can be performed in an edematous and ulcerated extremity without damage to the soft tissues; (3) the deep veins are more likely to be filled than in techniques in which the injection is made into a superficial vein of the foot or ankle; and (4) the injection does not produce thrombosis of the veins. The disadvantages are the requirement of a general anesthetic and the occasional extravasation of the injected liquid along the needle track into the soft tissues.

For visualization of the veins of the thigh the injection may be made into the tibial tubercle or a femoral epicondyle (Fig. 6). The veins about the hip, the pelvic veins, and the inferior vena cava are well shown by injections into the greater trochanter or head of the femur (Fig. 5). An injection into the superior ramus of the pubis demonstrates the pudendal, vesical, prostatic and presacral venous plexi and the obturator, superior gluteal, hypogastric, external iliac, ascending lumbar, medial femoral circumflex, and inferior gluteal veins (Figs. 11 to 15). Introduction of the opaque solution into the anterosuperior iliac spine outlines the superior and inferior gluteal veins, the hypogastric, external iliac, common iliac, presacral venous plexus, and ascending lumbar veins (Fig. 16).

In the upper extremities, the deep and superficial veins may also be demonstrated. The drainage in this region has been studied in cadavers by Harrison and Gossman. The solution injected into the acromion process may outline the cephalic and axillary venous system. From the head of the humerus, the venous drainage is into the cephalic, axillary, and circumflex humeral veins. From the olecranon process, the venous drainage is into the cubital, cephalic, and basilic veins. Injections into the lower end of the radius pass into the cephalic vein (Fig. 17).

Of particular importance is the demonstration of the paravertebral venous plexus.

Ever since Batson's (1, 2) demonstration of the extensive vascular network, its function has been the subject of speculation by many investigators, and the postulation has been advanced that it is the avenue by which many metastatic lesions are disseminated to the spine. Contrast material injected into the spinous process of a vertebra passes into the external and internal venous plexi of the vertebra injected and to the plexus above and below the level of the needle. These plexi can best be seen with the patient in a lateral position. These veins drain into the intercostal and azygos veins if the injection is made in a thoracic vertebra, or into the ascending lumbar veins and the inferior vena cava if the lumbar vertebra is used.

The internal vertebral venous plexus closely surrounds the spinal cord, and its demonstration should be of value in detecting neoplastic and other space-consuming lesions of the spinal cord, the surrounding meninges, and the spinal column. The azygos and hemiazygos veins are important veins in the mediastinum, and their demonstration may be of value in the diagnosis of mediastinal masses (Fig. 18).

Media injected into the sternum outline the internal mammary veins and their tributaries. Thus, veins in the anterior and posterior extremes of the mediastinum can be outlined by osseous phlebography.

This method of examination can thus be used to advantage in the demonstration of veins which are located deep in the body and which are otherwise inaccessible to the percutaneous injection of contrast media. It has proved to be a valuable method for the investigation of the etiology of diseases due to disturbances of the circulatory system. Recently, we have investigated the pathogenesis of osteitis pubis, the painful affliction of the pubic bones that generally occurs at varying intervals following prostatic resection. Figure 12 shows the drainage of contrast media injected in the normal pubis. Here opaque medium passes immediately into venous plexi behind the pubis and into the deep pelvic veins. In a case of osteitis pubis, the contrast medium remained in a plexus of tremendously dilated veins about the pubis. These veins corresponded exactly in location to the osseous lesions seen on the plain roentgenograms (Fig. 19). It was thus concluded that a thrombosis or occlusion of the veins draining the pubis, associated with secondary infection by saprophytic organisms, was the cause of osteitis pubis (19).

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EDITORIAL

THE CURRENT STATUS OF BLOOD VESSEL REPLACEMENT

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FOLLOWING THE INTRODUCTION of synthetic fabric for use as vessel replacement, the means for treating many patients with occlusive arterial disease or aneurysms became available to surgeons who had not had access to blood vessel banks. When it was recognized that the vascular surgeon no longer need be tied to the limitations of the often inadequate supply of tissue grafts from the vessel bank, a wide array of synthetic fabrics was put into clinical use, often without the critical testing and study which had characterized the development of the homograft. Responsible surgeons, as well as many without any reasonable background in the field of vascular surgery, not infrequently obtained materials for use in human patients from the stock of fabrics sold in a department store or dry goods outlet. To those of us who have studied vessel replacements since shortly after the introduction of preserved homologous arterial grafts to clinical surgery by Gross and his associates in 1949, our prime responsibility appeared to be that of counselling scientific restraint in the use of such materials until adequate animal testing had been accomplished with regard to the synthetic material as well as the type of fabric construction. Accordingly, we prepared a technical description of the synthetics being used and also analyzed samples of fabric being employed by a number of recognized vascular surgeons. Through the definition of terms alien to the medical vocabulary, and a description of the varying characteristics of synthetic materials and types of fabric construction, a greater awareness of the surgeon to the more desirable properties could be achieved.

It was interesting to us that the samples of fabric submitted by other vascular surgeons which we tested had many characteristics in common and it is fair to say that they all appeared to be reasonably well suited to clinical use. It is commendable that certain textile manufacturers have offered freely of their advice and services to medical investigators in respect to the testing of materials as well as to the construction of fabrics designed primarily for use in blood vessels. With the wider exploration of types of construction seamless tubes have been produced by weaving, braiding, or knitting techniques. While such a trend is commendable, it is unfortunate that a few commercial organizations have supplied the lay press with unsupported claims and have marketed insufficiently tested products across the counter of surgical supply houses without adequate control. Only time will tell whether patients have yielded a limb or their lives as a result of being made the testing ground for some new product. We cannot escape the responsibility for our patient's welfare when we insert a foreign body into his blood vessels. In some instances the textile industry has not shared this responsibility.

The need for some recognized group of informed individuals who could study and re-

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port on synthetic vascular replacements has been met by the appointment of special committees by the American College of Surgeons and by the Society for Vascular Surgery. These groups have as their goal the collecting of full technical data regarding all types of synthetic replacements being used in the vascular system and obtaining from responsible sources specific data as to the performance of such material in testing apparatus, in the experimental animal, and in the human patient. Although time will be needed for such data to delineate clearly the superior materials and types of construction from those which have been less satisfactory, there is no question that a positive step has been taken in the formation of these committees. From a preliminary evaluation of synthetic materials being employed for vascular replacement, certain information has been gained already.

With respect to tensile strength of a prosthesis, the factors of multiplicity of filament, denier[1] of yarn, and type of construction are very important. Most yarns employed in fabrication of prostheses contain 30 or more filaments subjected to moderate or slight twist. The denier of the yarn has been in general 70 grams or greater. In fact, with some of the seamless braided or woven tubes as heavy a yarn as 400 denier has been employed. In the consideration of tensile strength one must consider the basic construction of the prosthesis. Since the loop strength of the yarn is significantly less than the straight strength, the maintenance of tensile strength might be ultimately greater in a weave or braid construction than in a knit. Nevertheless, it would appear that all of the synthetic fabrics of 70 denier weight should function for a long time in the arterial system with the possible exception of nylon. We have observed 1 aneurysm in a nylon taffeta graft at 18 months in a dog. This fabric was constructed of 40 denier yarn, 96 by 144 per inch thread count.

It is thought by some that the retention of tensile strength of a synthetic material subjected to continuous stress in mammalian tissues may be related to the degree of moisture regain of the synthetic material. In support of this theory is the work of Poth, Moretz, Harrison, and others who have shown that nylon, which has up to 4.5 per cent moisture regain, appears to lose very significant tensile strength after implantation in mammalian tissues for a year or more. Such losses have not been observed with other synthetic materials such as vinyon-N or dacron which have a moisture regain in the amount of a fraction of 1 per cent. These observations raise a question as to whether nylon should be considered as completely satisfactory, even though it has had the longest trial in mammalian tissues as suture material and, as such, has the approval of the Food and Drug Administration. However, a recent ruling by the Food and Drug Administration designates synthetic grafts as "devices" and hence they are not subject to federal approval. This permits commercial use of the newer synthetics, such as orlon, vinyon-N, dacron, and teflon.

Although vinyon-N was the material from which the first successful fabric prosthesis was fashioned, it has the significant disadvantage of marked shrinking and stiffening when subjected to temperatures employed for autoclaving. Furthermore the commercial supply of yarn has been extremely limited in the past. In our experience, although teflon has certain qualities which theoretically might prove it to be superior, the synthetic which appears to be most suitable at the present time is dacron. This material has inertness in mammalian tissues, low water uptake, apparent retention of tensile strength after implantation in the mammalian tissues for over 18 months. Furthermore, the yarn can be fused with the actual cautery, a property which has importance in the preparation of certain woven synthetic replacements at the time of operation.

The question of carcinogenesis has been raised from time to time in regard to the use of plastic and synthetic materials in human

[1]Denier represents the weight in grams of 9,000 meters of yarn.

beings. It is worthy of mention that the long term testing in rodents of fabric made from certain of the synthetic materials already mentioned has not demonstrated carcinogenic properties (Oppenheimer, Oppenheimer and Stout). Furthermore, there have been no reports in the medical literature describing the production of a malignant growth by synthetic material implanted in a human being (Stout). This question has obvious medicolegal importance, and it is reasonable to state that to date the synthetic fabrics generally employed for blood vessel replacement appear to be entirely innocuous.

With respect to the specific properties of fabric which appear to be important in the field of vessel replacement, one must consider additional factors such as porosity, elasticity, and flexibility. Originally it was thought that the functional success of synthetic fabrics in contrast to failure with solid tubes of plastic material was related to porosity. Some support for this came from the experiments by Egdahl and his associates. However, laboratory trial of fabrics with very great porosity and extremely minimal porosity have failed to demonstrate a significant difference in functional success, which would certainly be expected were this characteristic so vital. Although some workers now disclaim any importance to porosity, there seems little question that with an open mesh it is possible for the fabric to become more firmly anchored in the host tissues by virtue of the ingrowth of fibroblasts through the interstices of the yarn. There is also evidence that the establishment of a new intimal layer is speeded when porosity is present. However, when porosity of a fabric exceeds 8 cubic feet of air per minute, there tends to be an excessive loss of blood through the fabric when circulation is re-established after implanting the prosthesis. Although the technique of preclotting the cloth with the patient's blood prior to implantation reduces such loss, there are some theoretic disadvantages and dangers related to this technique. Experiments are under way to investigate the ability of certain silicons to reduce blood loss yet maintain porosity in a fabric.

Elasticity as a property is outstanding in most tissue grafts but notably absent in most synthetic replacements. The weave construction, as well as braids and knits, require the use of many threads to the inch in order to achieve a reasonably low degree of porosity. As a result of this "packing" of yarn, elasticity is virtually absent in woven fabrics, and only slight in braids. Nevertheless, satisfactory function is observed. The greater elacticity achieved by knit construction, is generally dissipated when the replacement is fully distended under arterial pressure. Furthermore with the penetration and investment of the synthetic material by fibroblastic growth and ultimate scar, true elasticity is further reduced, as probably occurs with tissue grafts.

Flexibility or adaptability of synthetic fabric to pulse wave and to contour is probably a very important characteristic, although it has not yet been proved that this is the property upon which functional success depends. While most replacements do not alter their diameter or length significantly upon restitution of arterial blood flow, there is an adaptability of the replacement. Braid and knit constructions appear to be more adaptable than weaves, although functional success appears to be comparable in both types of fabric.

A feature of construction which warrants comment has to do with the seam. When a straight, curved, or bifurcation replacement is fabricated from flat fabric, double or triple seams have been sewn with a fine stitch adjustment on a standard sewing machine, with synthetic thread. In a few instances failures have been reported with such replacements in humans resulting from rupture of such a seam subsequent to implantation. The trend toward employing synthetic prostheses with seams woven by loom or seamless construction has been understandable, not from the standpoint of a seam contributing to thrombosis so much as from the greater strength of the replacement.

To our knowledge a properly constructed seam has rarely, if ever, contributed to thrombotic occlusion.

Failures of synthetic replacements have been primarily the result of thrombosis rather than rupture, among the collected experimental and clinical series in which woven, braided, or knitted replacements were employed. It is generally agreed that more meticulous technique is necessary during the implantation of a synthetic replacement than with tissue grafts, if one is to expect equivalent functional results. The estimation of diameters and length is more critical, because of the lack of a great elasticity or adaptability, and in areas where the "run-off" is poor or blood flow turbulent and slow, the presence of wrinkles or buckling of a replacement may well contribute to thrombotic failure. It is indeed unfortunate that the synthetic replacement is so much more readily available to all surgeons, rather than the homograft which demanded less technical skill of the surgeon. Despite most meticulous technique, results with synthetic replacements have still not been as good in peripheral arteries of patients suffering from arteriosclerotic occlusion as with homologous arterial or autogenous vein grafts. In our experience, homografts have been superior to venous autografts, a conclusion voiced also by Shaw and associates at the Massachusetts General Hospital.

Before passing to a consideration of tissue grafts in general, one should comment on the present status of ivalon replacements. In some areas, particularly in England and in the mid-western section of the United States, there is moderate enthusiasm for this substance. Before preparation, this material is an amorphous vinyl chloride polymer in sponge form. In order to withstand the pressures of the arterial system, the material must be compressed tightly and subjected to heat so that it will retain its form. In our experience, thrombosis, dilatation, and rupture of ivalon grafts in the thoracic aorta of dogs have occurred when the material was of inadequate thickness or was insufficiently compressed. In view of this danger, we have not considered ivalon as satisfactory as the types of synthetic replacements already discussed. The analysis of the case reports of about 500 human cases collected by the committee of the Society for Vascular Surgery and presented at the annual meeting in June 1956 revealed that more complications had occurred with ivalon than with any other type of prosthesis, especially in peripheral arteries. Its prime advantages appear to be ease of handling and facility of reproducing anatomic shape and form. It would seem wise to exercise caution in the use of this material until the relatively high incidence of thrombosis and rupture can be reduced in clinical cases.

An interest in heterografts has been displayed in Japan, France, and in America, again primarily because of ready availability. Experimental studies of such grafts, transplants from one species to another, have generally yielded discouraging results since they were first tried at the beginning of the nineteenth century. Considerable inflammatory reaction and necrosis of the graft were frequent observations, and thrombosis or rupture the end-result. Recently, chemical sterilization and freeze-drying techniques have modified the antigenic properties of heterografts in the opinion of some, to the extent that limited clinical use of such grafts in the iliac and femoral arteries has been reported with apparent functional success. Bovine or equine carotid arteries have been employed in most cases. Rosenberg and associates have recently reported on a collagen graft produced by enzymatic action of phycin on bovine arteries and implanted with functional success in the aortas of dogs. The use of this material has been experimental only, with an observation period of about 18 months. It is our opinion that at the present time, synthetic replacements offer perhaps more certain security for long term function than heterografts, regardless of the method of treatment.

Venous autografts are still favored by some surgeons who recognize the limitations of

synthetic replacements in their present stage of technicologic development and who have difficulty in obtaining homologous arterial grafts. Undoubtedly, adequate success has been achieved in short replacements for aneurysms of peripheral arteries, but a decreasing rate of functional success has been observed by some surgeons with longer segments employed for peripheral occlusive disease. In our experience, the results with long venous replacements for segmental occlusion has been far inferior to those enjoyed with arterial homografts, whether implanted as a by-pass or not.

In a consideration of the evolution or development of homologous arterial grafts, one must admit to certain advantages still not met by the synthetic replacement nor the autologous vein graft. While it is true that there are problems related to supply of such material, the criteria governing donor material have been gradually relaxed during the past 5 or more years. Some time ago, we demonstrated the suitability of arteries obtained 12 or more hours after death, provided the body of the donor was refrigerated without delay. A few years ago, Gross and his colleagues demonstrated that contaminated graft material could be effectively sterilized for clinical use. Once it had been demonstrated that retention of viability of a homograft was not essential to functional success, the various methods of electronic irradiation or chemical treatments could be applied for sterilization. Among the chemical agents, the current favorites are ethylene oxide or beta-propriolactone. Not long ago, homograft material from donors dying of generalized infection and even malignancy became acceptable, primarily because of the devitalizing effect of the methods of sterilization.

Extension of the period of storage by the use of quick freezing and freeze-drying techniques has permitted retention of graft material until the need for it arose. Unfortunately, improper application of freeze-drying techniques may split the wall of the graft and ruptures of homografts have been reported, presumably as a result of damage occurring at the time of freeze-drying. In our experience, simple rapid freezing and storage in an inexpensive insulated box filled with dry ice has been the most simple and satisfactory technique. We know of no actual limits to the period of safe storage by this technique, having implanted into dogs quick frozen grafts stored for as long as 4 years. These grafts have functioned satisfactorily for periods in excess of 1 year in the aorta of dogs. Clinically, we have employed frozen grafts stored for periods of over 1 year without difficulty.

From personal experience and that of others with synthetic and tissue grafts, there appears to be little difference in functional success with either in the aorta and iliac arteries when suitable synthetic material or aortic homografts were employed. In the peripheral arteries, however, homografts appear to be superior in patients with segmental occlusive disease. Failure because of thrombotic occlusion of the graft has occurred in 30 or more per cent of such patients with woven synthetic replacements, as contrasted to as low as 15 per cent with homograft by-passes in a group of patients followed for up to 16 months. In our opinion, the success rate with the by-pass type of graft has been greater than with excision and end-to-end technique. In addition, the preservation of the collateral arteries protects the patient, in the event that there is thrombotic failure of the graft. Our concern with homografts has of course dealt with the difficulty of obtaining material, particularly for use in peripheral arteries, but even more with regard to the experimental evidence of progressive deposition of calcium and destruction of elastic fibers in the wall.

We can predict that in time synthetic replacements will be available which will have the ease of handling of homograft material, and which will have even a greater guarantee of continued strength and stability. It would now appear that the ultimate fate of a synthetic replacement depends entirely on

the integrity of the basic synthetic material and construction of the prosthesis, rather than on the tissues of the host. At the present time, we believe homologous arteries to be superior for use in the treatment of peripheral occlusive disease, although some have had satisfactory results with autogenous vein grafts.

In view of the difficulty in maintaining a supply of homografts, the search should continue for more suitable synthetic replacements for peripheral arteries. An earlier resolution of technical difficulties and problems encountered in vessel replacement can be achieved if surgeons employ in patients only synthetic materials about which they have complete information, and if their results are reported in detail periodically either to one of the committees or in the literature. Furthermore, success of a graft often depends more on the clinical judgment in selection of the case and on the surgical technique than on the type of graft used. We think it not unreasonable that only surgeons with adequate qualifications and experience should assume the responsibility entailed in the use of vessel grafts, since failures occur in even the most experienced hands.

THE SURGEON AT WORK

MODERN TREATMENT OF PRURITUS ANI

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THIS PRESENTATION is based primarily on personal experience with over 1,000 cases of anal pruritus which were treated during a period of about 20 years. An attempt has been made to evaluate not only the new in the treatment of this distressing syndrome but the old as well. Therapy no longer offers the dilemma it once did even though the mechanism of pruritus in general has remained a complete mystery. However, the suggested newer forms of treatment are still legion and require dynamic judgment based on sound past experience with numerous therapeutic alternatives. Many times, therapeutic decisions are made without the knowledge of the exact cause or before nature has declared her hand.

The surgeon who treats anogenital pruritus must be an enthusiast. He should possess at least a modicum of psychiatric insight or orientation because many of these patients are psychoneurotic or motivated individuals. Some find their itching a psychologic need, the utilization and perpetuation of which seems to serve an important psychodynamic function. In general, the psychiatric factors of pruritus are still poorly understood; it is seldom clear what is cause and what is effect.

GENERAL MEASURES

Except for the acute cases, treatment is begun only after a thorough evaluation of the condition of the patient as a whole. It is essential to inquire as to status of nutrition and sensitivity to foods and drugs, and to ascertain the type of underwear. A diet well balanced and abundant in all vitamins, and particularly in vitamin B complex, is prescribed. In the presence of gastric hypoacidity or antacidity, glutamic acid hydrochloride is administered (6). Tea and coffee are eliminated because caffeine intensifies the central perceptibility of itching. Carbohydrates are reduced to prevent cutaneous hydration which may favor infection. Alcoholic beverages and highly seasoned foods are avoided because they intensify pruritus. On the other hand, phenobarbital and bromides control itching by depressing the central nervous system. However, because of possible habituation to barbiturates and the resulting prolonged drowsiness (hangover) a nonbarbiturate hypnotic is preferred for insomnia.

To date, personal studies of the alkaloid reserpine and its mother substance, rauwolfia serpentina, administered to over 30 patients revealed decided sedative and ataractic (tranquilizing) effects on most anxious patients but without apparent direct effect on the pruritus itself. With the aid of this medication, some of these patients tolerated the pruritus better only while they remained under therapy. Other investigators, believing with Stokes that pruritus is mainly a thalamic sensation, have most recently attempted to control pruritus by employing alseroxylon (a concentrate or fraction of the active alkaloids extracted from the root of rauwolfia serpentina) because of its allegedly direct central effect on the midbrain (midbrain sedative).

As reported by others, following prolonged reserpine therapy, particularly in high dosages, I have observed mental depression and diarrhea among other better known side effects. To avoid the undesirable side effects, especially diarrhea, of rauwolfia serpentina and its derivatives, I am now employing miltown (2-methyl-2-n-propyl-1, 3-propanediol dicarbamate) in a dosage of 400 milligrams given 1 to 3 times during the 24 hours.

I have not observed any side effects, adverse reactions have however been reported. These in-

clude cutaneous, muscular, gastrointestinal and paradoxic cerebral effects. The skin reactions are principally purpuric associated with intense pruritus which could be produced with 1 dose of 400 milligrams of the drug. Dependency on the drug (habituation) and undesirable withdrawal symptoms have also been observed.

Atarax, 1-(p-chlorobenzhydryl) - 4- [2-(2-hydroxyethoxy) ethyl] diethylenediamine, a potent tranquilizer, is being evaluated for regional pruritus. To date, in a dose varying from 10 to 25 milligrams given orally 3 times daily. Atarax has been very effective and devoid of side effects.

As a general policy, I prescribe a trial of estrogen replacement therapy when pruritus develops at or soon after the onset of natural or induced menopause (7). As the sole treatment, estrogens were effective in 19 women. Androgens were effective in 2 men with pruritus which occurred during the so-called male climacteric (5). As the sole treatment, insulin with a proper diet was effective in 3 patients with diabetes mellitus.

LOCAL MEASURES

The use of dry tissue paper is interdicted because it is rough and abrasive; moist cotton is employed instead. Soap is avoided and replaced by detergents. Colloid baths are useful in many instances.

In the presence of loose stools or a rectal discharge containing intestinal enzymes, the perianal skin is protected by the application of a bland cream to the perianal skin just prior to defecation. The bulk of the cream is removed after defecation (the Howard Lilienthal treatment).

I have abandoned the topical application of the derivatives of the cocaine group of drugs (ointment or suppositories) to the anogenital area because I have encountered an incidence of over 10 per cent of contact dermatitis with an aggravation of the pruritus following the employment of these local anesthetic agents. The seriousness of cutaneous sensitization of this group of drugs has been well appreciated and recorded by dermatologists. After a short trial, I have also discontinued the use of tronothane hydrochloride and dyclonine hydrochloride.

During the past 15 years I have not resorted to the perianal subcutaneous injections of either water or oil soluble, long acting anesthetic agents because, in my experience, these agents are unnecessary in the simple cases and are ineffective or useless in the refractory cases. Furthermore, these drugs may produce undesirable sequelae, such as paresthesias, and may cause complications, such as perianal and perirectal suppurations, necrosis, and incontinence; this is particularly true of the recently introduced efocaine (10).

In the past, I administered procaine hydrochloride orally to 7 patients with moderate to severe pruritus. This medication failed to relieve the pruritus in 6 individuals enough to warrant its further employment; vomiting followed its use in 1 patient. As a result of even this limited experience I have abandoned the use of orally administered procaine.

In general, the need for superficial roentgenray therapy has been decreasing in proportion to the development of newer and more effective therapeutic agents. In the past, irradiation was extremely useful in intractable cutaneous lesions and for concomitant hyperhidrosis. More recently, however, I have administered anticholinergic drugs such as probanthine (propantheline bromide) or prantal (diphemanil methylsulfate) for the successful control of hyperhidrosis in 18 patients; these drugs failed in 6 other patients.

Antihistamine drugs (8) applied topically in 1 to 3 per cent concentration controlled pruritus in 45 patients but caused moderate to severe contact dermatitis in 8 of these individuals. While the local application assures a high concentration of an antihistamine drug without causing systemic side effects, the high incidence of contact dermatitis limits, or even precludes, its use except in very selected cases. These drugs probably act against the antihistamine release mechanism; they are not necessarily antiallergic.

Brossy observed that the hydrolamins have been ineffective in the commercially available ointment form. This observation is in agreement with my experience. This also applies to topically applied vitamins, particularly of A, D, and E.

The application of a combination containing 5 per cent of sodium caprylate and 5 per cent sodium propionate in aquaphor, a detergent skin cream containing hydroxyl animal fats, was effective in over 100 patients, especially in the aged (39 patients) who may have suffered from a reduction or absence of the normally present lower fatty acids in their skins. These drugs are also antiseptic and antifungal. They are partic-

ularly valuable in controlling anal pruritus which is a manifestation of the side effects of the broad spectrum or other antibiotics (12).

Mycostatin, taken orally or applied topically, is effective in many cases of pruritus that are caused by fungi and yeasts.

Corticotropin and the steroid hormones have been employed in over 250 cases. ACTH or cortisone, administered parenterally and orally respectively, as the sole treatment for severe itching, was found to be extremely useful in patients with anogenital pruritus which was associated with the moist type of lichenification of the involved skin. ACTH is particularly valuable during the acute exacerbations of this condition (9). These agents are decidedly useless for pruritus that is not associated with cutaneous changes. Although the good results lasted for a brief period of time in the preponderance of cases, these hormones, by temporarily holding in abeyance or reversing the pruritic process, afforded an opportunity to study the patient and to institute basic or rational measures to control the underlying and precipitating cause or causes of the pruritus. The employment of these agents nowise alters the effects of any diagnostic procedures including that of skin testing, nor of any other concomitantly employed therapeutic agents.

Hydrocortisone, free alcohol or acetate, applied topically in a concentration of 1 per cent is also morbistatic and hence a valuable symptomatic agent for the suppression or control of certain types of anogenital pruritus (11). This hormone is effective against most (but not all) instances of intractable pruritus that is associated with moderate lichenification of the perianal skin of less than 3 years' duration. But, in most of these cases, the daily application of this medicament is necessary for the maintenance of relief; without continuation of therapy "lasting relief" is almost an illusion. Furthermore, the need for continual application of this, or any other, medication *by the patient* to the anogenital area, which is an erogenous zone, carries the oft unrecognized risks of perpetuating or even increasing the severity of pruritus. Hydrocortisone should not be used promiscuously or indiscriminately as seems to be the present trend. In the chronic cases with advanced lichenification of over 3 years' duration the response was slow and required prolonged and frequent application of hydrocortisone. Recurrence of pruritus was noted in all of these cases immediately upon cessation of treatment.

Hydrocortisone is completely ineffective for pruritus which is not associated with skin changes. As a group, these patients are neurotic with a great anxiety component. Since regional itching is seldom a monoetiologic condition one therapeutic agent can hardly be used successfully to the exclusion of other rational forms of treatment. Hydrocortisone is also practically ineffective in anal pruritus that is secondary to diarrhea, antibiotic therapy, enterobiasis, pediculosis, or the accompanying moisture-producing anorectocolonic lesions (11).

Hydrocortisone may be combined with oxytetracycline or another antibiotic in the treatment of pruritus that is associated with open, secondarily infected lesions. In 3 instances, following the topical application of neomycin, I have observed a dermal type of contact dermatitis and pruritus with negative patch tests quite similar to that described recently by Epstein. A delayed reaction to intradermal testing proves contact sensitivity to this antibiotic. I have not yet encountered this type of cutaneous sensitivity with negative patch tests following the application of other antibiotics. To date, no systemic effects have been observed following the topical application of hydrocortisone, nor has a single instance of allergic sensitization been reported.

Hydrocortisone constitutes a significant therapeutic development, but like the other members of the glucosteroid adrenal cortical hormones or corticotropin, it does not cure any morbid process. Whereas symptomatic relief is obtained, permanent alteration of the basic disease is not accomplished. Inability permanently to eliminate the underlying and precipitating causes makes the institution of radical forms of therapy necessary, or even mandatory, because intractable pruritus can become an insatiable process that may occupy all the patient's energies and attention.

Recently, 9-alpha fluoro-17-hydroxycorticosterone-21-acetate (fludrocortisone) in concentrations of 1/10 per cent and ¼ per cent has been given a trial. Thus far, this product, in the concentrations employed, was superior to ordinary hydrocortisone in 2 cases, but in 1 instance the pruritus and irritation were intensified when this drug was applied to an acutely inflamed perianal skin. In this last instance the possibility of percutaneous absorption with systemic manifestations

such as edema was suggested for the first time (11). These observations have since been confirmed.

At the time of this writing, prednisolone, the delta-1 analogue of hydrocortisone applied topically in a cream in a concentration of 0.5 per cent or administered orally or parenterally, is receiving a clinical trial. Of the 25 topically treated patients, 2 have failed to respond; 1 of these 2 patients subsequently responded to ordinary free alcohol hydrocortisone while the second patient responded promptly to fludrocortisone after he also failed to benefit from ordinary hydrocortisone. After discontinuation of therapy, the pruritus of 5 patients promptly recurred. Retreatment with the prednisolone cream again brought about relief. In 1 of these 5 patients, parenterally administered prednisolone in dosages of 35 milligrams daily for 5 days, brought about relief from pruritus for over 2 weeks while the same hormone given orally in a dosage of 40 milligrams daily was considerably less effective for the control of the third relapse. These facets of the problem are under continued study. Prednisolone, administered orally and parenterally, is said to possess increased potency and is not likely to interfere with water and sodium metabolism (fluid retention).

The effectiveness of the topical application of a number of other steroid hormones has been subjected to clinical assessment. Studies to date reveal that (1) an ester of hydrocortisone and (2) an ester of prednisolone, appear to have decided merit. However, both esters are provided in oleagenous (petrolatum) bases because the esters hydrolyze in the presence of water and hence would be stable for a few days only in water containing vehicles.

1. Hydrocortisone diethylaminoacetate hydrochloride (magnacort) is available in a 0.5 per cent concentration. It is lipophobic and soluble in water to the extent of 150 milligrams per cubic centimeter in contrast to hydrocortisone free alcohol of 0.28 milligram per cubic centimeter or hydrocortisone acetate of only 0.01 milligram per cubic centimeter. In this concentration this new compound has at least therapeutic value of 1 per cent of hydrocortisone free alcohol or hydrocortisone acetate, and in some cases it is superior to hydrocortisone.

The lipophobic nature of this ester is believed to enhance its departure from the petrolatum vehicle into the aqueous phases of the skin. Once in the skin, its water solubility enhances its dispersion and penetration, while its lipophobic nature is believed to keep the hormone within the skin for longer periods of time and to discourage penetration into the lipoid and fat found deeper in the skin. Confirmatory studies of this is now in progress with the aid of radioactive hydrocortisone diethylaminoacetate.

2. Prednisolone diethylaminoacetate is a water soluble ester of prednisolone which is also lipophobic. Since this substance, milligram for milligram, is twice as potent as prednisolone it is provided in a 0.25 per cent concentration. This substance is being evaluated.

All derivatives of the steroid hormones may be combined with other antipruritic agents; they thus supplement rather than supplant older but established drugs. The combination of pantothenylol and hydrocortisone has no superiority over hydrocortisone used alone.

I eliminate proctologic lesions that are associated with pruritus ani regardless of their etiologic connection with the pruritus. In 290 patients lasting relief could not be accomplished from any form of antipruritic treatment until associated proctologic lesions, especially those which produce moist irritating discharges, were extirpated. Moreover, the character of these lesions justified the surgical removal in their own right even when there was no pruritus present. Each patient was dealt with as an individual problem. This policy is the result of my growing experience and was adopted after carefully trying out alternative therapeutic methods and is also quite widely accepted by numerous proctologic surgeons and progressive dermatologists.

The need for radical surgical forms of treatment, particularly the sleeve resection of the perianal and anal skin, has disappeared. This procedure is a mutilating operation requiring a prolonged convalescence and I have never found it necessary for pruritus; this is a good operation used for the wrong purpose. In 30 cases, the undercutting operation of Ball produced short-lived relief from pruritus which did not, as a matter of practical therapeutics, justify my subsequent employment of this surgical procedure. The so-called clover-leaf operation which consists in the removal of a large block of pruritic skin from each quadrant of the perianus has been effective in 110 instances of otherwise refractory pruritus that was not associated with cutaneous changes. However, I am not ignoring

or overlooking the psychotherapeutic implications of this or any other procedure employed in this group of patients many of whom are neurotic or motivated individuals. Here, fine judgment based on a rich experience is essential.

The need for subcutaneous injection of ethyl alcohol is disappearing rapidly. The method originally described by Harvey Stone in 1916 is safe. I have used it in the distant past in over 50 cases with variable success but without serious complications. Alcohol, being a lipoid solvent, dissolves the myelin sheath of the nerve (lipoid component) and leaves the axon (protein component) intact. Alcohol produces degenerative changes in the cutaneous sensory terminals which result in cutaneous anesthesia that lasts until regeneration of the nerve takes place. However, some of the modifications of the Stone technique, notably the Buie procedure, are not safe as they may cause: (1) extensive slough of the skin, of the subcutaneous tissues, and even of the sphincter muscle resulting in incontinence; (2) suppuration of the perianal or perirectal structures; and (3) contracture of the anal canal requiring corrective surgical procedures.

Tattooing of the pruritic skin with mercury sulfide, though employed less frequently now than in the past, benefits permanently those patients whose pruritic skin is lichenified and who have obtained temporary relief readily from either ACTH or glucosteroid adrenal cortical hormones. I now employ these hormones as a test preliminary to tattooing; the quick responders appear to be good candidates for this therapeutic procedure. Furthermore, tattooing is the least drastic of the radical procedures and, unlike the subcutaneous injections of alcohol, is free from gross or microscopic complications. Histologic examination of skin made a decade or more years after tattooing with mercury sulfide has failed to disclose evidence of a foreign body giant cell reaction.

As a result of my experience since 1938 with over 200 cases, I have observed that: (1) tattooing of the pruritic skin with mercury sulfide was of no value in pruritus that is not associated with characteristic cutaneous changes; (2) it produced unpredictable results in pruritus that is associated with dry, tense, pruritic skin; and (3) excellent results followed tattooing of moist lichenified anogenital pruritic skin in the absence of anorectocolonic disease (7). For the treatment of this last group of patients, tattooing remains an extremely valuable therapeutic procedure.

In a word, it is apparent that although the recent therapeutic advances have forced many retreats they have not yet indicated an easy appraisal and treatment of anogenital pruritus.

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TRANSVESICAL REMOVAL OF DISEASED URETERAL STUMP

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IN MOST INSTANCES when a nephrectomy is performed a portion of the distal ureter is not removed. Fortunately, this ureteral remnant is rarely the cause of later symptoms. However, when it contains a stone, is infected and obstructed distal to ligation, or contains residual tumor, unfortunate sequelae may result. In many such cases, symptoms of ureteral disease may occur years later and frequently resemble those for which nephrectomy was done. A patient with a stone in the retained stump may complain of lower quadrant pain on the side involved. When the retained stump is discharging pus into the bladder, symptoms of acute or chronic cystitis will usually be present. Generally, an infected ureteral stump will discharge into the bladder; however, in 1 patient in our series 4 explorations of the nephrectomy wound were performed for a draining nontuberculous sinus. Eventually, a pyoureteral stump was demonstrated to be draining from the proximal end rather than into the bladder as one would expect.[1] Simple removal effected a cure. The finding of residual or recurrent papillary tumor in the distal retained ureter years after nephrectomy for papillary carcinoma of the renal pelvis or ureter is so common that nephroureterectomy is almost universally recommended for these lesions.

Diagnosis of a diseased ureteral stump may be confirmed at the time of cystoscopy and is usually recognized by visualizing pus exuding from the ureteral orifice on the suspected side. Usually the stump can also be filled by retrograde injection of the radiopaque dye. However, when the diagnosis cannot be positively established, a carefully taken history, evaluation of the patient's symptoms, comparison of prenephrectomy and postnephrectomy roentgenograms, and review of all pathologic reports may give enough information to warrant exploration of the retained ureteral stump.

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[1]MASON, J. T., and COBURN, W. A. Disease of ureteral remnant following nephrectomy. Arch. Surg., 1955, 70: 280–282.

Exposure and removal of the diseased ureteral stump have heretofore most often been accomplished by using a midline or a Gibson[2] type of incision and approaching the ureter and deep pelvic structures through the retroperitoneal space. In our hands, this exposure has proved difficult and often hazardous because of the proximity to large vessels, scar tissue, and extreme depth of the wound. Furthermore, it has not always been possible to be positive that the entire ureter has been removed.

It has been demonstrated previously that the normal ureter is freely movable in the retroperitoneal space and can be pulled directly into the bladder. Because of this fact, the author believed that a transvesical approach to the diseased ureteral stump could be accomplished. Anatomic studies have also shown that the internal and external longitudinal muscular layers of the ureter fuse with the bladder musculature at the ureterovesical junction. The middle circular layer of ureteral musculature does not fuse with the bladder. Waldeyer's fascia, a part of the endopelvic fascia, surrounds the ureter at its vesical terminus where it is continuous with the vesical fascial sheath. Waldeyer's fascia is better developed in some cases than others forming a glovelike sheath for 3 to 4 centimeters of the most distal ureter. It was reasoned, therefore, that if a circular incision was made about the ureteral orifice, including the ureteral meatus and a few millimeters of bladder wall as a cuff, the entire diseased stump of ureter could be pulled directly into the bladder once the dissection had been carried through the bladder musculature to Waldeyer's sheath. This procedure has been proved clinically.

The operative technique is as follows: The bladder is opened suprapubically. The ureteral orifice is identified and a bent silver probe inserted (Fig. 1). A circular incision is made about the ureteral orifice down through all layers of the bladder musculature to the ureter. Waldeyer's

[2]GIBSON, T. E. Quoted in Dodson, A. I. Urological Surgery. Pp. 363–365. St. Louis: The C. V. Mosby Co., 1944.

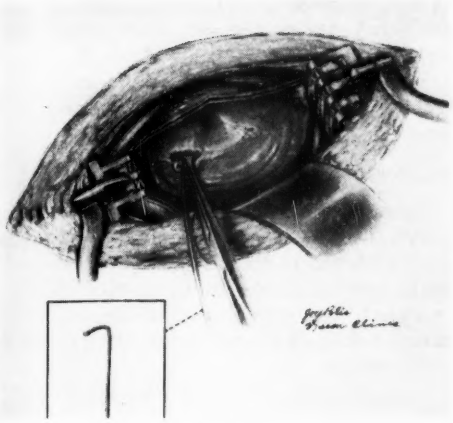

FIG. 1.

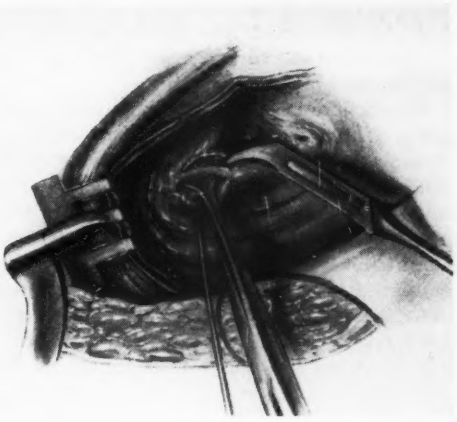

FIG. 2.

FIG. 3.

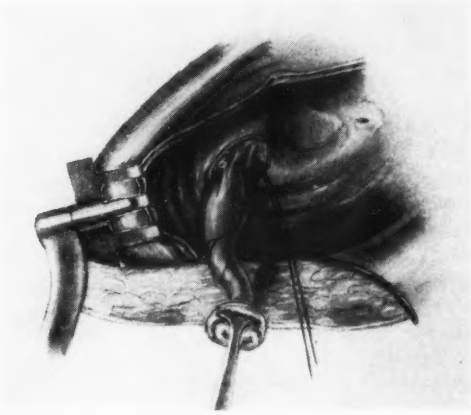

FIG. 4.

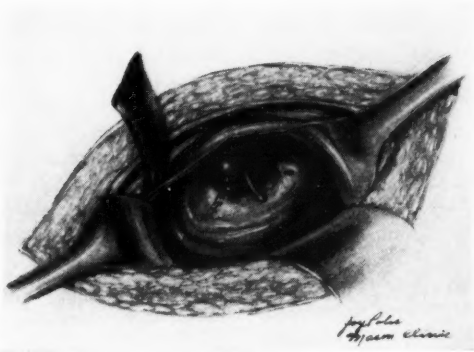

FIG. 5.

fascia may or may not be demonstrable (Fig. 2). After the distal ureter has become freely mobile, the probe is removed and gentle traction is applied to the ureteral stump (Fig. 3).

As adhesions are separated, the stump is easily delivered into the bladder. Bleeders which are on the medial side are ligated and cut in the usual manner (Fig. 4). The proximal end of the diseased ureter is easily identifiable in most cases. Often, the site of previous tie can be seen. After removal of the ureteral stump, the circular incision through which the ureter has been pulled is closed with a series of interrupted sutures in the muscle and in the mucosa of the bladder (Fig. 5). A drain is placed down the lateral side of the bladder to the point from which the ureter has been removed, the area having been opened by blunt dissection. The bladder is closed completely, and a urethral catheter is left in place for approximately 6 days and the drain for 10 days.

SUMMARY

Removal of a diseased ureteral stump by using previously recommended approaches is often quite difficult. In selected cases "pull through" of the ureteral stump into the opened bladder is proposed. This type of surgical approach often makes a difficult operative procedure comparatively simple.

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A BRIEF ACCOUNT OF THE DEVELOPMENT OF THORACIC SURGERY AND SOME OF ITS CONSEQUENCES

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IN 1896 A BOOK BY STEPHEN PAGET, entitled, *The Surgery of the Chest* was published. This was after many abdominal operations had become commonplace. The book is very interesting, especially because of the graphic account of some of the early attempts at pulmonary resection. Those attempts were confined almost entirely to the treatment of pulmonary tuberculosis. Although Tuffier of Paris and Lowson of London in 1891 and 1893 respectively each succeeded in the surgical removal of the apex of a tuberculous lung the many other attempts were tragic failures, including the case of an unnamed surgeon who committed suicide to escape a "judicial enquiry" because of the death of a woman patient from whom he attempted at one sitting to remove the tuberculous apices of both lungs. Paget's opposition to the idea of pulmonary resection, at least in tuberculosis, is tersely expressed in his statement, "the surgeon need not be afraid that it will ever be his bounden duty to resect the apex of the lung for phthisis." As an appendix to his book Paget adds an address given by Reclus before the French Surgical Congress in 1895. To illustrate the contemporary opinion of pulmonary resection I quote two of the conclusions: "Resection of tuberculous masses ought to be proscribed" and "resection of a part of the lung for primary malignant disease is not even worth discussing."

In spite of a reasonable ability to cope with infection because of the acceptance of the Listerian principles and to prevent surgical shock by the control of hemorrhage, a much higher mortality accompanied intrathoracic operations than those performed in the abdomen. It was readily apparent that the factor chiefly responsible for the difference in mortality was the disturbance of the normal intrapleural pressure relationships by the admission of air through the incision. Indeed it seems fair to state that the factor most important in the retardation of the development of chest surgery was the fear of the consequences of an open pneumothorax.

The realization of the importance of preserving the so-called "negative" pressure in the pleural space had led Sauerbruch (46) in 1904 to devise a chamber which actually amounted to a small operating room. The body of the patient and those of the surgeon and his assistants were inside the chamber which had a pressure less than that of the atmosphere and the heads were outside. Any device as cumbersome as that could hardly be expected to become popular, and actually it did not.

Chest surgery had to wait for a more simple method of avoiding the consequences of an open pneumothorax. It came in 1909 in the invention of insufflation intratracheal anesthesia by Meltzer

This was the first annual Rollin T. Woodyatt Memorial Lecture delivered at Thorne Hall, Northwestern University Medical School, Chicago, May 20, 1955. The first part of the lecture, which was a tribute to Dr. Woodyatt, has been published separately in the *Quarterly Bulletin, Northwestern University Medical School*, 1956, 30: 286.

and Auer, then of the Rockefeller Institute. Although several earlier workers had devised methods of instituting positive pressure within the lungs to prevent pulmonary collapse when the pleura was opened, the method of Meltzer and Auer recommended itself by its simplicity. It permitted the administration of an inhalation anesthetic at the same time that it allowed a surgical incision through the pleura. There is no doubt that this simple device has been one of the most important foundation stones upon which the structure of modern chest surgery has been erected.

In spite of the great importance of this simple method of avoiding the collapse of the lung it was used very little before the first World War largely because there were very few surgeons prepared to undertake intrathoracic operations, in addition to the fact that the diagnosis of intrathoracic disease was far from accurate.

With the advent of that war and a large number of chest wounds that forced themselves upon the attention of the military surgeons it became evident that much confusion existed regarding the effects of an open pneumothorax. It must be recalled that at the time there were no satisfactory x-ray films of the chest or even fluoroscopy because the Coolidge tube, which made the x-ray examination of the thorax feasible, was not invented until 1917.

The prevailing idea was that the mediastinal pleura constitutes a more or less rigid partition between the two pleural spaces so that the result of an open pneumothorax on one side was the collapse of the corresponding lung but with practically no effect on the opposite lung. The importance of this concept was that it indicated that the former fear of a pneumothorax associated with an intrathoracic operation was groundless, because the worst that could happen would be the temporary collapse of one lung. Many surgeons with experience in removing shell fragments from the chest without any special equipment for combatting the effects of pneumothorax were impressed and astonished by the fact that there could be any survivors of such procedures. They drew extravagant and unwarranted conclusions therefore that no special protection against the effects of pneumothorax are necessary. Duval of the French army, who had probably the largest experience in removing foreign bodies from the chest, and the great Moynihan of the British army gave the dangerous impression that the long standing fear of pneumothorax should become obsolete and that actually operations in the chest could be performed with the same safety as those in the abdomen and without heed of any complications from the pneumothorax.

An accurate knowledge of the effects of pneumothorax was needed not merely because of academic interest but rather because it was of fundamental importance for the future development of chest surgery.

If one could disregard the pneumothorax factor and perform an intrathoracic operation with no more hesitation than an intra-abdominal procedure, then obviously the development of chest surgery could proceed without delay.

It was my good fortune to be allowed with R. D. Bell (28), during our military service in the first World War, to make an experimental study of this question. The main conclusions that were drawn from the work were that: (1) in a normal chest, without thickening of the mediastinal pleura, when the pressure was altered in one pleural space nearly the same change occurred in the pressure of the other pleural cavity. This finding therefore meant that an open pneumothorax on one side affected both lungs, although not quite to an equal degree. (2) A unilateral open pneumothorax is fatal if the opening is too large. The maximum size of the opening that can be withstood by the patient is dependent to a great extent upon his vital capacity. If the latter is high a much larger opening can be withstood than if it is low. If the vital capacity is so greatly reduced that its value approximates the tidal air requirement then the individual will succumb to a very small opening in one pleura.

The immediate applicability of those conclusions to the treatment of the acute streptococcal empyema which was then raging in the U. S. Army camps was at once apparent because the usual manner of treating empyema was to resect a rib and establish open drainage of the involved pleural space as soon as a diagnosis of empyema was made. Actually the mortality from that disease was greatly reduced as a result of our observations. Probably more important, however, was the fact that a clearer understanding of the effects of an open pneumothorax laid to rest the mistaken idea that intrathoracic operations could be performed with a complete disregard of precautions to avoid the harmful effects of an incision into a pleural space. At any rate, upon

the termination of the war the knowledge and the means were at hand to proceed with the development of the surgery of the last body cavity which hitherto had resisted the efforts of the surgeons.

Our recommended plan for the treatment of the acute empyema associated with the streptococcal pneumonia was to aspirate at intervals or to use closed drainage until the exudate was actual "creamy" pus and then to resort to open drainage, usually with resection of a small piece of rib. This procedure usually required about 10 days. By carrying out such a plan one could avoid the harmful effects of an open pneumothorax in patients who, because of the presence of an extensive pneumonia, were already dyspneic and often cyanotic. By delaying the open drainage until the pus was "creamy" one opened into an abscess instead of into the free pleural cavity. Moreover even if some air did enter the pleural cavity it did but little harm because the clearing of the pneumonia had allowed the vital capacity to become greater. Also the mediastinal pleura had become more stabilized as the result of edema and some inflammatory induration so that it was less likely to be crowded over into the other pleural cavity and compress the other lung.

During the last war the value of the old operation of decortication was greatly amplified and applied to cases of early empyema resulting from retained blood in a pleural cavity. This was the work of Burford, Parker, and Samson, and it constitutes an important advance in the treatment of wounds of the chest.

It would be beyond a reasonable scope for this article to undertake to review in any detail the numerous accomplishments which have been achieved and have resulted in a step by step conquest of this field. Instead only certain highlights will be discussed. The contributions to our knowledge which came along after World War I and led to the present remarkable state of chest surgery have been both general and specific. By *general* I mean that they have been applicable to surgery in general, and by *specific* I refer to the working out of certain definite operative procedures within the chest.

Of the contributions of a general nature there are three that stand out conspicuously. These are blood transfusions, better and safer anesthesia, and the antibiotic drugs with which to combat infection. As one who pioneered in the early work in chest surgery before there were transfusions and antibiotics it seems to me remarkable, looking back, that any of our patients survived the operations performed on them. The younger surgeons of today can hardly realize the contrast between "then and now" in the confidence with which the surgeon can undertake a difficult operation. The high operative mortalities which accompanied our work constituted a vicious circle. The only patients referred to us were those who were in bad condition from chronic infections or from advanced development of their ailments. Our lack of conspicuous success with many of those about to die led in turn to our failure to obtain patients in good enough condition for the operations to justify any reasonable optimism in the surgical treatment of the given diseases. Thus the vicious circle went on.

It was probably only natural and to be expected that the first serious intrathoracic undertakings were directed at the lungs because of their large size and accessibility. The pandemic of streptococcal pneumonia during the two successive winters of 1917–1918 and of 1918–1919 had left in its wake a very large number of cases of nontuberculous pulmonary infections. Particularly prevalent were bronchiectasis and chronic lung abscess.

It was obvious that removal of the diseased tissue should be recognized as the only treatment for the condition of bronchiectasis that would offer hope of a cure. Anyone who saw a lung affected by this disease with the sacs of dense fibrous tissue containing quantities of thick malodorous pus could easily recognize the futility of any procedure aimed at a restoration, by any method, of the lung tissue to normal. Everything else short of resection could at best be only palliative. The trouble was, however, the high mortality associated with the operation of lobectomy. Although occasional operations for the removal of a bronchiectatic lobe had been successful before World War I, probably, if the truth were known about unreported unsuccessful attempts, the mortality would have been found to be shockingly prohibitive. Lilienthal's report of his 42 cases of lobectomy for suppurative disease was the first considerable series, and although he had a mortality of 64 per cent he was able to demonstrate that at least some of the survivors were satisfactorily cured and restored to health. In spite of the high mortality his series encouraged others to undertake the operation of lobectomy.

Those surgeons who today are accustomed to a mortality of about 1 per cent for lobectomy can hardly appreciate the nerve wracking procedure the operation was in the 1920's. The disease processes were extreme, the patients were almost always in very poor condition and, even if death did not occur on the operating table, there was an inevitable serious and usually putrid infection of the wound which followed the operation. Regardless of how the bronchial stump was treated it practically always reopened. Metastatic abscesses of the brain occurred frequently and often made their presence known just at a time when the surgeon was beginning to feel assured that the patient was about to recover from the operation. But even if he did go safely through the ordeal of the lobectomy and avoided a later fatal brain complication, he was not always well. He was likely to be improved symptomatically but a residual focus of bronchiectasis in another part of the lungs which had been missed in the original examination might cause the symptoms to be nearly as severe as they had been before the lobectomy. Moreover the profuse expectoration which was usually the chief reason for the patient's desire to have an operation might persist because of a chronic bronchitis resulting from incurable nasal sinus disease.

It is little wonder, therefore, that as experience increased a feeling of futility about the operation should arise, with the result that lobectomy was practically abandoned. Other surgical procedures were therefore introduced of which perhaps two deserve mention. One was the operation of thoracoplasty introduced for this purpose by Hedblom, and the other was called, for want of a better name, "cautery pneumectomy," introduced by the writer (27). There is no doubt that some patients were greatly relieved of their excessive sputum by thoracoplasty but the operation failed to carry out what was recognized as the essential procedure in this disease, namely, the removal of the diseased tissue. The operation of cautery pneumectomy destroyed the involved part of the lung by means of an actual cautery in multiple stages. It was realized that from a surgical standpoint, it was a poor substitute for a one stage lobectomy and that some day it would be supplanted by a more desirable procedure. Yet, as a stopgap it served its purpose fairly well. In the author's hands of 54 patients, 36 or 66.6 per cent were enough improved to return to normal activities and only 6, 11 per cent, died.

In 1929 a strange event occurred. Harold Brunn, a member of the American Association for Thoracic Surgery, read a paper before that Association describing his experience with 6 one stage lobectomies. Four patients were listed as cured, 1 improved, and only 1 died. Although this was a small series the results were the best so far reported. No important new principle was added to what the rest of us had practiced for several years. Yet the results were much better. As a consequence of his report everybody at the meeting was stimulated to try the one stage lobectomy again. There is no doubt that it was owing to Brunn's presentation at that meeting that a discredited operation was brought back into favor. A remarkable feature of the episode was that everybody else's results improved over what they had been, and the mortality rates became respectable, in spite of the fact that nothing new was contributed.

Nowadays cases of bronchiectasis like those commonly seen in the 1920's no longer occur. They were essentially complications of suppurative pneumonitis and pulmonary abscess, conditions which fortunately generally are prevented by the antibiotics from occurring. Thus 3 of the conditions which provided indications for surgical intervention during the developmental period of chest surgery have nearly disappeared. I refer to postpneumonic empyema, lung abscess, and bronchiectasis.

As the operation of one stage lobectomy became safe and more refined so did the diagnosis. Better bronchograms by the use of lipiodol which had been introduced by Sicard and Forestier in 1922 revealed the fact that in many cases of bronchiectasis the disease was confined to only a part of one lobe. Also Brock (12) observed that pulmonary abscess usually occurred in the posterior segment of the right upper lobe or in the apical segment of each lower lobe. Somewhat similar observations on segmental anatomy led Churchill and Belsey (18) to undertake in suitable cases of bronchiectasis the removal of only the part of the lobe in which the disease had been demonstrated, thus often conserving a considerable part of the lobe which formerly would have been sacrificed. This was an important contribution and in turn it was followed by a more intensive study of the anatomy of the lobes of the lung. The classic studies of Brock (14) and of Jackson and Huber in mapping the various segments of the pulmonary lobes not only revealed what was

surprising to many, namely, that there were still original observations to be made in gross anatomy but they paved the way for the important work of Overholt in boldly reviving interest in the treatment of pulmonary tuberculosis by the deliberate resection of diseased portions of the lobes. The anatomic studies of Blades and Kent on the location and distribution of the lobar bronchi and blood vessels were very important in improving the operation of lobectomy.

It should be recalled that the first surgical treatment of pulmonary tuberculosis was the resection of the diseased apex of a lung, in 1 case by Tuffier, and in another by Lowson. The procedure fell into disrepute and, except for occasional instances of accidental resection of tuberculous tissue when the operation had been undertaken for the removal of a supposedly nontuberculous lesion, a period of nearly 50 years elapsed during which a direct attack on the tuberculous lung was taboo. Now it would seem, however, as if the indirect surgical methods of treating pulmonary tuberculosis are destined to play a minor role. All of those methods, except the direct drainage of cavities, are based on the principle of relaxation or of compression of the diseased lung. The chief one is the operation of thoracoplasty. This operation has gone through many modifications since Brauer and Friedrich laid the foundations for the more modern procedures. To Sauerbruch (47) and John Alexander, especially the latter, we are particularly indebted for modifications of the early operations. It would seem as if perhaps there will always be cases of tuberculosis in which some kind of relaxation or compression of the lung, as by thoracoplasty, instead of resection may be indicated but they will certainly become less numerous as time goes on. This remarkable revival of interest in surgical resection as a recommended procedure in the treatment of pulmonary tuberculosis could not have occurred without the discovery and use of streptomycin, PAS, and isoniazid. Who can tell what may happen in the next few years? If a more effective antibiotic is discovered perhaps tuberculosis will go the way of postpneumonic empyema, of lung abscess, and of bronchiectasis. Then the discussion of methods of resection or of relaxation of the lung will be largely of historic interest.

The next subject of major interest involving the lungs which I should like to discuss is that of cancer. Unlike the inflammatory conditions that have been the subjects of our discussion that are showing a marked decline in incidence, bronchiogenic carcinoma is rapidly increasing. Since there is as yet no known antibiotic or other drug that affects this disease appreciably, the only known effective treatment is surgical eradication. It is therefore the responsibility of everybody engaged in clinical medicine, whether general practitioner or chest surgeon, to acquaint himself with the known facts of this important and fatal condition in order to recognize and treat early the patients who have it. It is not generally appreciated what cancer of the lung has been doing in the last 20 years in its race to become one of the principal killers.

Figures of death rates in the United States compiled by Hammond and Horn show that in 1930 cancer of the lung in men was credited with fewer deaths than each of the following: cancer of the skin, of the liver, of the rectum, of the intestine, of the prostate, of the stomach, fewer than pulmonary tuberculosis, and the combination of pneumonia and influenza. During the next 20 years, however, although the death rates for the other cancers showed little change, that for cancer of the lung increased enormously. Actually in 1950 the deaths from bronchiogenic cancer in men exceeded the number of deaths from any of the other cancers, including cancer of the stomach which formerly was the leading cause of cancer deaths. Moreover in that year the death rate of lung cancer equalled that of pulmonary tuberculosis and almost equalled that of pneumonia.

I shall not enter into a discussion of the possible explanation of the enormous increase of bronchiogenic carcinoma. Instead I should like to dwell on a few other aspects of the problem.

Perhaps some do not realize how very recent the modern treatment of this cancer is and are not aware of the fact that probably the first patient to be permanently cured of a bronchiogenic cancer is still alive (29). He is a doctor who continues to practice in Pittsburgh. I stated that he was probably the first patient to be cured of a bronchiogenic carcinoma because I have been unable to find in the literature any case report of a patient who has lived more than 5 years after an attempt to remove the cancer in which the diagnosis was unequivocally established by microscopic examination. Moreover that patient represents the first successful total pneumonectomy for cancer and the first successful total

pneumonectomy performed in one stage for any cause.[1] The operation was carried out as recently as April 5, 1933, only 23 years ago. It is true that in 2 previous instances, one by Nissen in 1931 and the other by Haight in 1932, the hilum of a lung had been ligated followed by a sloughing out of the organ. Both patients were children. Nissen's was a case of bronchostenosis after trauma and Haight's a case of severe bronchiectasis. In neither case could the operation be considered a one stage pneumonectomy. Now, of course, the operation of one stage total pneumonectomy is a procedure which is performed almost daily in the large thoracic surgical centers. Although the percentage of 5 year cures in cases of bronchiogenic carcinoma is still discouragingly low even after total pneumonectomy, it is probably no exaggeration to say that at least several hundred people a year are now being cured who otherwise would die of their cancers. The ultimate answer to this problem seems to me to consist of two parts. The more important part is to do away with the carcinogenic agent which is responsible for the disease in the first place, and the other part is to try to get those patients earlier who permit their cancers to develop in spite of very strong evidence already at hand that heavy cigarette smoking is an important etiologic factor.

The operation on the Pittsburgh physician was performed at a time when our knowledge of the mechanism of pulmonary embolism was much less extensive than now. When after getting the exposure a decision was reached to remove the whole left lung, my greatest worry was concerned with what might happen in a patient, 48 years of age, as a result of a sudden occlusion of the left main pulmonary artery. Would the procedure give rise to the effects of a pulmonary embolism? From animal experiments it seemed probable that the ligation of one of the two main branches of the pulmonary artery would not be fatal. Neither the report of Nissen's nor of Haight's case was known to me at that time. Nissen had published his report in a rather obscure journal and Haight had not yet published his case. At any rate, even if I had known about them, since both of those patients were children, 12 and 13 years old respectively, I should still have wondered if a middle-aged patient could endure with the same impunity the sudden blocking of the circulation to one entire lung. Of course the obvious thing to do was to put the question to a direct test in such a manner that any harmful result could be immediately stopped. Accordingly the artery was dissected out and a rubber catheter was passed around it. I asked the anesthetist to watch carefully for any danger signals when I tightened the catheter. When nothing happened I felt it was safe to proceed with the pneumonectomy.

A matter of human interest about this patient shows how lucky I was to have so optimistic and stoical a person for my first pneumonectomy. When our bronchoscopic biopsy showed an undoubted cancer I told him about it. He asked to go home for a few days to arrange his affairs before the operation. When he returned I learned that he had gone to his dentist to have some cavities filled, but—and this is a strange contrast—he also bought a cemetery lot. Every surgeon knows it is of the greatest help to have an optimistic patient. The visit to the dentist by this patient gave me great assurance.

At present the most popular operation for cancer of the lung is total pneumonectomy because that operation gives a better opportunity to eradicate all of the disease, including mediastinal lymphatics, than a more simple lobectomy. Various modifications have been proposed from time to time, for the most part in an attempt to make the procedure more radical. Nevertheless one should not lose sight of the fact that in some patients the loss of a lung results in an almost intolerable invalidism. These patients are commonly designated as "respiratory cripples." In some the dyspnea is so great that it is only with much difficulty that they can walk across a room. Under such circumstances such questions arise in the mind of both the surgeon and his patient as, "Has the operation been worth while? Is there any satisfaction in going through a heroic procedure to cure a cancer only to be made a hopeless invalid?" Churchill (19) and his associates have made a serious study of this question. In a preliminary report they advocate the performance of only a more simple procedure of lobectomy instead of pneumonectomy when the patient is likely to be made a respiratory cripple by the removal of the whole lung. If there were available a simple test for respiratory

[1]MacEwen of Glasgow is sometimes credited with having performed the first pneumonectomy. However, it seems to me very unlikely that he did remove a whole lung, since there was no specimen to examine afterward, and there is no satisfactory description of how he handled the bronchus and large blood vessels. It seems more probable that he merely cleaned out a giant cavity.

function it would be most valuable in helping to decide what sort of an operation should be performed in some of the doubtful cases. As yet there are not available a sufficient number of cases of cancer treated by lobectomy alone to inform us of the chance of a 5 year cure. However, even if a cure can not be expected, there may still be justification for the removal of only a lobe if by so doing one can get rid of the main infected mass of cancer together with the lobe infected as a result of the atelectasis caused by bronchial obstruction. Further study of this whole question is needed.

The esophagus has attracted the attention of the surgeons for a long time. Indeed in the year 1913, preceding World War I, there occurred the successful performance of two classical operations. One of those was the famous resection for carcinoma by Torek which was the first successful operation for cancer of the esophagus. The other was the well known operation by Heller of Germany for cardiospasm or achalasia. In my opinion the Heller operation remains the simplest and most successful procedure so far devised for that condition. I have performed it many times with almost uniformly good results. Adams and Phemister originated a fairly simple procedure for cancer of the lower end of the esophagus. Sweet, perhaps, has shown to be obsolete the principle of the Torek operation—the removal of the entire thoracic esophagus with the creation of a cervical esophageal fistula and a gastrostomy, although Watson has recently revived it. Sweet has demonstrated that instead of using the Torek operation it is possible to bring the stomach up into the thorax sufficiently high to anastomose it to the pharynx. Allison has contributed much to our knowledge of the origin and prevention of peptic erosion of the esophagus after anastomotic operations. The technical features of operations on the organ seem to have been rather satisfactorily worked out so that today the operative mortalities are low even for the most extensive procedures. Unfortunately, however, the problem of cancer of the esophagus remains one that is far from solved. The percentage of good 5 year results is discouragingly small. The fundamental problem in that condition is earlier diagnosis and therefore earlier application of our well known surgical procedures. But usually the first symptoms which bring the patients to their doctors for examination are those of difficulty of swallowing, a condition which indicates at least a partial obstruction. By that time the cancer is generally too far advanced to be amenable to a cure by surgical means.

A discussion of the newer surgery of the heart has been postponed until the last because in reality most of the exciting development in this field has occurred very recently, in fact since the end of World War II.

Praise should be given to Claude Beck for his indefatigability in striving to improve the circulation of the myocardium by several ingenious methods and for his pioneer work in resuscitating the heart in cardiac arrest.

The idea of a surgical correction of a stenosed orifice in the heart is by no means new. Lauder Brunton is generally given the credit for first proposing in 1902 that some day it might be possible to correct a mitral stenosis by surgical means. The idea must have occurred, however, to many pathologists before that time while examining a heart with that condition at autopsy. It occurred also to Duff Allen and me, and in 1922 we cut the leaflets of the mitral valves in dogs with practically no mortality under direct vision by means of an instrument designed by us called a cardioscope. The approach to the valve was made through the left auricular appendage. The 1 patient to whom we sought to apply the procedure died on the table before we could put the instrument into the heart and, in addition to our feeling that perhaps the procedure was too experimental, we failed to get another patient. Cutler, using a slight modification of our instrument, was able to report in 1924 the results in 5 cases of human mitral stenosis. One patient who lived for 4½ years after the operation had a result which greatly benefited her. In 1925 Souttar reported his now famous case of finger dilatation of a stenosed mitral valve. Although the patient survived and received much benefit, Souttar has told me himself that he was never able to obtain another patient. A surgeon who has to depend on his medical colleagues for patients should choose his colleagues wisely. The rest of the story of the attack on mitral stenosis is well known. The contributions to this subject of Smithy, of Bailey and his associates and of Harken have solidly established a surgical treatment of this condition. Essentially, however, it is the original Souttar method.

I shall not discuss in any detail the successful achievements and the disappointments in the

surgical attacks on the other valves or on the congenital defects of the heart. The story is probably rather well known to most of you anyway. I went into some detail in regard to the surgery of the mitral valve because, from a historical standpoint, that was the first point of attack by those who were trying to develop the new field of intracardiac surgery.

One cannot leave this subject, however, without paying tribute to Alfred Blalock who started a new chapter in surgery when in 1945 he successfully operated on his first case of Fallot's tetralogy. The operation was not a flash in the pan or the result of any accidental discovery. Rather it was the culmination of years of experimental work during which he perfected his technique of blood vessel surgery. To paraphrase Pasteur, it can be said that when the right case came along it met the man prepared to cope with it. We should also, however, honor Russell Brock (13), Willis Potts, Robert Gross (31), and others who have made their very important contributions to the solution of the problems of congenital heart disease. In this connection also Bjork should be mentioned for his stimulating physiologic contributions to our knowledge of the circulation and respiration. Gross (30) and Crafoord independently established the surgical correction of coarctation of the aorta, a procedure that also opened the door for the fascinating work in resection of aortic aneurysms by De Bakey (20) and his pupils.

It has long been a rule in surgery that it is always preferable to have good exposure for any operation so that one can see plainly what he is doing. Operations on the inside of the heart to correct septal defects and regurgitant lesions of the valves have met with difficulties because it is not a simple matter to have a relatively bloodless organ which will permit a free incision with good exposure of the inside. Various ingenious methods have been devised to overcome those difficulties which I shall not take time to discuss here. There are two, however, that deserve particular mention. One is the creation of an extracorporeal circulation of blood by means of an artificial pump which forces oxygenated blood through the tissues as the heart is by-passed. The originator of this method is John Gibbon. The other is the use of hypothermia which, by lowering the need for oxygen through the body, permits the surgeon to shut off the blood to the heart sufficiently to allow the performance of an operation within the heart if not more than a few minutes are needed. Bigelow, and Swan, deserve particular honor for their pioneer application of this method to intracardiac surgery.

Another ingenious method devised for permitting a free incision into the heart is that recently reported by Lillehei (55) and his associates. It makes use of the principle of cross circulation so that the patient's blood can be constantly oxygenated by the lungs of a donor and then returned to the patient.

The multiplicity of the procedures used in the development of intracardiac surgery proclaims the difficulties involved and actually tends to explain why this work is all so recent. In fact the surgery of the inside of the heart closes the last anatomic frontier of the surgeon's art. Of course, there will always be new operations and modifications of operations that are now being used. But there is no considerable area of the body remaining which has so far escaped surgical attack. Every organ has now been operated on frequently for a variety of conditions.

Does this mean that surgery is becoming a closed chapter? Are there still opportunities for research? If so, what directions will they take?

I have said[2] that the anatomic frontier is now being closed. But there is a wide and far-reaching physiologic frontier which is just beginning to be explored. By this I mean, for example, the many problems involved in the study of the disturbances of the patient's metabolism produced by his disease and by the trauma of the surgical operation. Many important contributions to our knowledge of these subjects have already been made. But too little is known today about the processes of repair which enable a patient to recover from an operation. For example, almost nothing is known even about the mechanisms of wound healing. Lister showed us the desirability of keeping bacteria out of the wound, and more recently we have learned the importance of vitamin C. But we know practically nothing of the enzymes that must be at work to form adult scar tissue from the fibroblasts, to stimulate the epithelial cells of the skin and mucous membranes to grow and cover the scar tissue in an orderly manner and then to stop, or the fundamental processes that result in the development of new bone. These are essentially chemical phenomena

[2]From this point onward I have borrowed liberally from a previous article of mine: Changing conceptions in surgery. Postgrad. M., 1950, 7: 154-156.

which should be of the greatest interest to the surgeon.

Today we are probably too willing to accept the idea that from 8 to 10 days are required for the healing of an uninfected wound as if this time were unchangeable. On the other hand, if we could understand better the fundamental chemical processes, might we not look forward to the time when the healing of an ordinary wound would require perhaps only 2 or 3 days and the healing of a fractured bone only 2 or 3 weeks?

The physiologic frontier is capable of indefinite expansion if we think of a surgeon as one who is interested in something more than cutting and sewing. If he has scientific curiosity, why should he not be interested in the causes and detailed pathogenesis of the diseases themselves? We can go further and ask, why should he not be interested in developing methods of treatment other than by operation? Would it not be an exciting adventure for a surgeon to discover a method of dissolving gallstones and urinary calculi in situ so that operations for these conditions would become at least infrequent or even obsolete? The surgical literature, as a matter of fact does record numerous instances of experimental attempts by surgeons to find such methods. Would not any surgeon be happy to discover a method which would eradicate cancer by the simple use of the hypodermic syringe?

I mention these few examples merely to emphasize the fact that although the anatomic frontiers of surgery are just about closed, the physiologic frontiers are wide open and extend quite indefinitely.

It is not a new concept that the surgeon is able to make important discoveries in physiology. Indeed a large number of such discoveries have been made by surgeons. As examples there can be offered much of our knowledge of the functions of the thyroid, of various parts of the brain, certain aspects of the physiology of respiration and of digestion, important features of metabolism, and most of what is known about surgical shock.

Only recently, however, have any considerable number of young surgeons undertaken a serious study of chemistry in order to equip themselves for an attack on those problems which come particularly within the surgeon's field. It seems to be a relatively new concept for surgeons to equip themselves in a field apparently as remote from the operating room, as is chemistry, to help close some of the physiologic frontiers of surgery. Yet the young surgeon, Lister, was able to see the applicability of the work of the young chemist, Pasteur, on the fermentation of wine to the problem of wound healing. Could anything at the time have seemed more remote from the operating room than Pasteur's work on the fermentation of wine? It is to be hoped that in the near future these chemically and physiologically trained young surgeons will accomplish much in the conquest of disease which, I take it, is the goal of surgeons as well as of all others interested in medicine.

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Reviews of New Books

THE BOOK entitled *An Atlas Illustrating the Topographical Anatomy of the Head, Neck, and Trunk*[1] by the late Johnson Symington of the Anatomical Department, The Queen's University, Belfast, was first published in 1917. Later increased in extent, the atlas now "contains 34 detached plates of 36 life-size horizontal sections through the head, neck, thorax, abdomen and pelvis, with seven reconstructions, also life-size." The plates are placed in a portfolio, an arrangement which, as noted in the prefatory remarks, permits removal and arrangement "conveniently for the comparison of adjacent sections."

While, of course, serviceable, the plates are not executed in the best tradition of either the anatomist's or the illustrator's craft. The labels are not uniformly abbreviated, the words on a single plate are derived from anglicized and the latinized lists of terms. Detail in pictorial structure is generally wanting.

Recognizing that reciprocity in bookish dealings has not yet become an actuality, the value of the set to the British student or surgeon may conceivably be high. But for this country, Professor Symington's *Atlas* offers nothing new or needed, since we have the reprinted form of *A Cross-Section Anatomy* by A. C. Eycleshymer and D. M. Schoemaker, with half-tone figures prepared from the superb drawings by Tom Jones, now Emeritus Professor of Medical and Dental Illustration, in the School of Medicine of the University of Illinois. The latter illustrations of 113 sections and 14 key figures were executed in meticulous detail. In respect to pictorial excellence, inclusiveness and publishing judgment, the Eycleshymer-Schoemaker volume attained such perfection as to render idle any attempt to produce a similar treatise. —*Barry Anson.*

THE 1,387 PAGE VOLUME entitled *Actas y trabajos del VI congreso latinoamericano de neurocirugía*[2] is the record of the eminently successful neurosurgical meeting which was held in Montevideo in March 1955. The papers are printed in Spanish, Portuguese, French, and English, and the participants in the program, together with others in attendance, represent most of the countries of the Western Hemisphere and Europe, the U.S.S.R. excluded. Special recognition is due Sr. A. Weinberger for his excellent translations of the summaries of each paper.

The subject matter of the Congress is divided into 5 main parts: the cisternal hernias, the surgery of pain, the dyskinesias, a symposium on the thalamus, and various subjects of general interest. The papers are apparently printed in their full form (but it is noteworthy that none of them appears "padded"), all are well illustrated, and the summaries will no doubt add to the general attractiveness of this excellent book. The names of many important clinicians and investigators are to be found on the roster of the program.

The subject of cisternal hernias (as in acute increase of intracranial pressure after trauma) is necessarily largely clinical in nature, but the 2 opening papers by Carrillo and associates (Buenos Aires), and Ghersi (Buenos Aires) indicate the wide scope of the anatomic pathology encountered in this condition, and how the clinical approach can be made more secure through the use of iodoventriculography, a method long in use in neurosurgical circles in South America.

Papers on the use of leucotomy in intractable pain, on tractotomy at the various levels (with demonstrations of operative technique, surgical anatomy, and clinical results), on the "special" neuralgias (as trigeminal neuralgia), and on sympathectomy for pain, leave the reader with the impression that for all the earnest endeavor of neurosurgeons the world over to find the surgical answer to pain, there is not much recently new on the subject, and that clinical results, be they good or (as is often the case) something less than satisfactory, are obtained only at a cost to the patient. The much debated operation of Taarnhoj seems generally conceded to be effective only because of the operative trauma to the trigeminal root, rather than to any "decompressing" effect.

The treatment of the dyskinesias, both medical and surgical, is reviewed in the third section of the book. There is an extensive critique of cortical and subcortical extirpation, tractotomy, pedunculotomy, Fenelon's ansotomy, and the ligation of the anterior choroidal artery. Quite typically, each participant has his own pet operation based on *his* understanding of the pathologic anatomy, but, in sum, none of the operations seems to in any way nearly approach an ideal. The difficulty in absolute identification of the anterior choroidal artery, and the many variations to which it is subject, are stressed.

The symposium on the thalamus is for the most part investigative in nature, with excellent presentations by Jasper (Montreal) and Walker (Baltimore). A particularly outstanding feature is the 115 page atlas of photomicrographs on the ultramicroscopic structure of the thalamus by Fernández-Morán (Caracas). The illustrations are particularly fine.

The fifth section of the book deals with craniocerebral trauma, injuries of childbirth, intracranial tumors and infections, cranioplasty, aneurysms, special diagnostic uses and methods of angiography and pneumoencephalography, and various other practical clinical subjects. This is the least distinguished section of the book.

As would be expected in such a large compilation of papers on related subjects, there is a good deal of reduplication from author to author in the references to

[1] AN ATLAS ILLUSTRATING THE TOPOGRAPHICAL ANATOMY OF THE HEAD, NECK, AND TRUNK. By the late Johnson Symington, M.D., F.R.C.S., F.R.S. (A portfolio containing 34 plates.) $21.00. Reprinted and published for the Anatomical Society of Great Britain and Ireland. Edinburgh and London: Oliver and Boyd, 1956. (Distributed in the United States by Charles C Thomas, Publisher, Sprinfield, Ill.)

[2] ACTAS Y TRABAJOS DEL VI CONGRESO LATINOAMERICANO DE NEUROCIRUGÍA. BAJO LOS AUSPICIOS DEL GOBIERNO DEL URUGUAY CON LA COLABORACIÓN DEL CENTRO DE COOPERACIÓN CIENTÍFICA PARA AMÉRICA LATINA DE LA U.N.E.S.C.O. 1,387 pages, illustrated. Montevideo, Marzo 21–24, 1955.

the literature, quotations, and recounting of historical facts, yet there is no feeling of redundancy as one progresses through the book. Much of the best information and most entertaining reading is to be found in the discussions. Throughout the book one finds the blunt, factual, realistic, down-to-earth, and steadying words of experience from such men as P. Wertheimer (Lyon), Bailey (Chicago), and Horrax (Boston). The book is rich in bibliographic references, and it is well indexed, beautifully printed, and well bound. It is a useful addition to any medical library.

—*John Martin.*

THE SYMPOSIUM OF ARTICLES dealing with the general subject of bone neoplasms which constitutes the volume entitled *Clinical Orthopaedics*,[3] should prove of interest and value not only to orthopedic surgeons but to general surgeons and radiologists as well.

The book consists of a series of 15 brief papers of which 7 deal with the commoner forms of bone tumor, and the remainder cover a group of more unusual varieties and include reports of rare or atypical entities.

An excellent biographic sketch of the late Joseph Colt Bloodgood is presented by Charles F. Geschickter, a long time associate, and serves as an introductory feature.

The study made by Murray M. Copeland of the subject "Tumors of Cartilaginous Origin" is noteworthy for its correlation of the benign and malignant forms of cartilage growths. The profession needs to be reminded constantly of the possible serious implications of tumors of cartilage origin and the tendency in a substantial percentage of cases toward transition, often by insensible gradations, from benign to malignant.

The important subject of osteogenic sarcoma is dealt with in 2 papers, the first by Henry L. Jaffe and the second by Irving Stein and Martin L. Beller. Jaffe separates the fibrosarcomas of bone and the chondrosarcomas from the general group of osteogenic sarcomas. His paper is concerned with malignant connective tissue tumors which show evidence of osteogenesis. This is in line with the concept held by others both here and in England, and serves at least one useful purpose. The true osteosarcomas have a somewhat poorer prognosis than do the fibrosarcomas of bone and primary chondrosarcomas, while the secondary chondrosarcomas have much the brightest outlook. Five year survival rates of osteogenic sarcoma mean little unless the figures are compiled for each of these component types separately. Jaffe calls attention to a distinctive variety of bone-forming tumor, i.e., the juxtacortical osteogenic sarcoma which has been termed "parosteal osteoma" by Copeland and Geschickter. This uncommon lesion is worthy of consideration because it runs an unusual clinical course and its ultimate serious potentialities are not often appreciated.

Stein and Beller have condensed into a small space much of the current knowledge of osteogenic sarcoma. Ewing's sarcoma, primary reticulum cell sarcoma of bone, and plasma cell myeloma are discussed by McCormack, Orringer, and Phelan. They emphasize the difficulties of diagnosis from roentgenographic findings, and the overemphasis of some of the earlier statements of "typical" features seen on x-ray films. Fortunately these facts are now becoming more widely recognized. The similiarity of histopathologic findings in Ewing's sarcoma and metastatic neuroblastoma and reticulum cell sarcoma of bone is well demonstrated and is, of course, clearly understood by pathologists who are called upon to differentiate between them. The authors, in summarizing, wisely emphasize the need of teamwork on the part of the surgeon, the pathologist, and the roentgenologist, for a correct diagnosis is essential to proper therapy.

The same subject is further discussed by Walker and Jones. They properly condemn the therapeutic trial of irradiation as a substitute for biopsy, and assert that the latter procedure should offer no hazard to the patient. We strongly support their conviction that many of the reported *cures of Ewing's sarcoma* are really cures of reticulum cell sarcoma, and we agree that for reticulum cell sarcoma irradiation is preferable to radical surgery.

Fibrosarcoma is covered by Ivins, but his paper is concerned with soft part tumors rather than true fibrosarcomas of bone.

Unfortunately, space does not permit a detailed review of the other excellent contributions which make up this worthwhile volume; suffice it to say, it provides in a convenient, condensed form much valuable information for the surgeon who is called upon to treat neoplastic lesions of the skeletal system.

—*Bradley L. Coley.*

EARLY IN HIS MEDICAL CAREER Dr. Henry Gans became intensely interested in anatomy of the liver. The volume entitled *Introduction to Hepatic Surgery*[4] is an outgrowth of these early studies. The main thesis of this text concerns detailed anatomic studies of the intrahepatic tributaries of the bile ducts, hepatic vein, portal vein, and hepatic arteries, and the significance which the distribution of these structures has in relationship with operations on the liver. The anatomic observations are based largely on careful study of corrosion specimens of human livers, mostly normal but some diseased. It is the author's opinion that hepatic surgery has not progressed, as far as surgery of the lung, because of failure to recognize and appreciate in a practical surgical manner the true anatomic distribution of blood vessels and bile ducts within the hepatic parenchyma. He suggests principles of "hepatic surgery based on the morphology of the liver." The morphology which he describes in considerable detail is somewhat at variance with previous concepts. He advocates ligation at the hilus of the liver of vessels and ducts which supply that part of the liver which is to be resected followed by ligation at the cranial pole of the liver of the corresponding branches of the hepatic vein. He states that lines of resection in the liver should then

[3] CLINICAL ORTHOPAEDICS. No. 7. TUMORS OF BONE. Edited by Anthony F. DePalma. With the assistance of the Associate Editors, the Board of Advisory Editors, and the Board of Corresponding Editors. 354 pages, illustrated. $7.50. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

[4] INTRODUCTION TO HEPATIC SURGERY. By Henry Gans, M.D. With an introduction by A. Brunschwig, M.D. 265 pages, 120 illustrations. Amsterdam. Houston, London, New York: Elsevier Publishing Co., 1955.

be carried along the relatively avascular division which his studies show within the hepatic parenchyma.

Clinical application of the anatomic observations described in this book is limited; however, several chapters are devoted to surgical indications, approach, and preoperative and postoperative care of patients who have operations on the liver. This presentation should be of interest to anyone who contemplates hepatic surgery and may well result in stimulation and further accomplishment in this relatively unexplored field. There are many references both historical and current. —*James T. Priestley.*

THE TINY BOOK entitled *Die Kolposkopie in der Praxis*[5] is an indispensable gem for anyone who wants to learn how to use the colposcope. Except for 4 short introductory chapters the book is really an atlas. There are magnificent color photographs under each of which is a written description of what is shown in the photograph. On the page opposite the photograph is a labelled sketch of the tissue depicted in the colored illustration. In addition, under the pen sketch there is a photomicrograph of the lesion and a description of it. Therefore, as one looks at the two facing pages, he sees all the data of the particular lesion illustrated and described. The book contains 40 colored photographs, 40 pen sketches, and 40 photomicrographs, all of which are beautifully reproduced.

Whereas colposcopy is in common use in the German-speaking countries, in Spain, in South America, and elsewhere, it is seldom used in the United States except perhaps in Philadelphia.

Both the author and the publishers are to be congratulated on this masterpiece because anyone who has attempted to take and reproduce colored illustrations of tissues inside the vagina will appreciate the difficulties and patience involved. —*J. P. Greenhill.*

THE FOREWORD of the most excellent monograph *Clinical Measurement of Uterine Forces in Pregnancy and Labor*[6] states: "It is written for those obstetricians and clinical investigators who must teach, study, and discuss new facts about the mechanism of labor and the effect of drugs, emotional states, and clinical procedures upon the course of gestation and labor."

The book is divided into 4 main parts: (1) the historical background and physiologic basis for tokodynamometry; (2) the various methods in the use of the tokodynamometer; (3) the physiology of uterine contractions during pregnancy and in normal and abnormal labors. This part is of practical value to every obstetrician in that the normal and abnormal patterns of uterine contractions are discussed in reference to their clinical application. (4) A discussion of the effects of the psyche and various drugs on uterine contractions comprises the last 4 chapters, and the author's interpretation of the results obtained are both interesting and informative.

In view of today's frequent use of oxytocics, particularly intravenous pitocin, in the management of the obstetric patient the last chapter on the effect of pitocin on uterine contractions is most timely. The authors analyze the effect of oxytocics, the various routes of administration, and the indications, contraindications, and dangers in their use. The authors' discussion of safety factors in the clinical use of intravenous pitocin and their recommendation of a safety dose for its use during labor should be known to every physician who cares for the obstetric patient.

This book is of great value to obstetricians and those who are interested in the clinical investigation of obstetrical problems. —*Magnus P. Urnes.*

THE SMALL TEXT from Great Britain entitled *Gynaecological and Obstetrical Anatomy and Functional Histology*[7] is in its third edition in 10 years. It presents the structural anatomy of the female pelvis and correlates structure with function. Although this correlation primarily emphasizes obstetrics, there is a chapter devoted to ovarian function and another to the anatomy of prolapse. Extragenital pelvic anatomy is included. Each section of the text includes a discussion of the embryology of individual organs.

Although the book adds little to standard descriptions in purely anatomic texts, the excellent clinical applications of the anatomy described should make understanding and retention of pelvic anatomy more complete for students of obstetrics and gynecology.
—*Frank M. Maher.*

THE DIFFERENTIAL DIAGNOSIS OF DISEASES is presented by Harvey and Bordley[8] in a most interesting and highly instructive manner by the use of case material from The Johns Hopkins clinical-pathologic conferences. The interpretation of clinical evidence, the subtitle of their book, follows the Cabot type of case report as further advanced by clinicians Thayer, Hamman and the authors, with pathologic analysis by MacCallum and Rich.

The cases selected for interpretation, as indicated in the preface, are primarly those in which clinical studies were carried out in the past 10 years so as to include the diagnostic procedures currently in use. The exceptions involve material of unusual interest. The authors point out that all diagnosis must be differential before it can be of any use, and that both the bedside clinic and the clinical-pathologic conferences have helped to remove the subject from the realm of dogma. The presentation of each diagnostic problem simulates the condition under which physicians must actually work, beginning with the complex and working toward the simple. In the discussion of methods and principles of differential diagnosis it is emphasized that the physician must begin first by marshalling all of the facts, then proceed with an unprejudiced analysis of the facts, and end with a logical conclusion. In 13

[5]DIE KOLPOSKOPIE IN DER PRAXIS; EINFUEHRUNG IN DIE GYNAEKOLOGISCHE KREBSFRUEHDIAGNOSTIK. By Privatdozent Dr. med. Herbert Cramer. 103 pages, 80 illustrations and 40 color illustrations. DM 30.— Stuttgart: Georg Thieme Verlag, 1956.

[6]CLINICAL MEASUREMENT OF UTERINE FORCES IN PREGNANCY AND LABOR. By S. R. M. Reynolds, Ph.D, D.Sc., Jerome S. Harris, M.D., and Irwin H. Kiaser, M.D., Ph.D. 328 pages, 99 illustrations. Springfield, Ill.: Charles C Thomas, 1954.

[7]GYNAECOLOGICAL AND OBSTETRICAL ANATOMY AND FUNCTIONAL HISTOLOGY. By C. F. V. Smout, M.D., M.R.C.S., and F. Jacoby, M.D., Ph.D. 3rd ed. 336 pages, 185 illustrations. $7.00. Baltimore: The Williams & Wilkins Co., 1954.

[8]DIFFERENTIAL DIAGNOSIS; THE INTERPRETATION OF CLINICAL EVIDENCE. By A. McGehee Harvey, M.D., and James Bordley, III, M.D. 665 pages. $11.00. Philadelphia, London: W. B. Saunders Co., 1955.

of the chapters, the student is given the opportunity to follow the process of differential diagnosis as it was actually employed by others in clinical-pathologic conferences.

The chapter headings represent important signs or symptoms which may be caused by several different diseases, while the discussion which follows the case history is exactly the same as that offered at the conference before the correct diagnosis was revealed by the pathologist. The reader is enabled to develop a sound approach to differential diagnosis by observing both the successes and the failures of those experienced in the field. Tabulation of methods of reasoning are offered in the various chapters.

In the case discussions, the authors are repeatedly concerned with the problem of distinguishing between significant and insignificant facts. They stress that differential diagnosis comes from the case history, physical examination, ancillary examinations involving special techniques, and laboratory methods, together with an observation of the course of the illness. The physician must begin his analysis of the facts not only by determining their relative and intrinsic significance, but by considering their relation to the patient's total illness. The subjects include: aortic insufficiency, heart failure, pain in the chest, sudden death, failures of urinary excretion, hematemesis and melena, jaundice, hepatomegaly and ascites, lymphadenopathy and splenomegaly, fever of obscure orgin, diseases involving the lungs or mediastinum, meningitis, and special diagnostic problems; including the diagnosis of certain rare diseases.

Unknown cases for study are presented, as a final chapter, in a form which permits the reader to make his own analysis as it took place in the clinical-pathologic conference. The conclusion reached, both by the reader and by the discusser, may be checked against the autopsy findings. Laboratory values of clinical importance and a most complete index are provided at the end of the text.

The authors have presented a remarkable collection of data concerning the differential diagnosis of disease in brief, easy to read discussions which should prove to be of great value both to the medical student and the man, in the practice of medicine or surgery.

—George C. Turnbull.

THE SMALL MONOGRAPH[9] on the surgery of maxillary and perimaxillary infections by Yoel and Bilesio initiates a series of writings by various contemporary Argentinian authors on medical specialty subjects. This book is divided into two parts, the first being devoted to maxillary infections, and the second to perimaxillary infections.

From a practical viewpoint the maxillary infections resolve directly or indirectly into a study of osteitis or osteomyelitis, for which reason the entire first part of the treatise is a comprehensive discussion of these disorders in their acute and chronic phases. Each salient feature is given a practical turn exemplified by a case history. The colored illustrations, demonstrating the course taken by suppurative processes, are as informative as any currently found in the literature. The effects of specific infections such as actinomycosis, syphilis, and tuberculosis with their diagnostic differentiation are well handled.

Among the therapeutic agents described ozonotherapy is recommended as an extremely important and successful method; ozone frequently gives rapid relief of pain, inflammation, and definitive curative acceleration.

Cellulitis constitutes an integral segment of the problem of perimaxillary infections. The extension of the infectious process into the sinuses with involvement of the various neck and facial glands, particularly the parotid gland is detailed sufficiently to make the reading of this work worth while. The standard set by this volume makes succeeding volumes of this series desirably anticipated.

—Stephen A. Zieman.

THE BOOK entitled *Office Gynecology*[10] fulfills the author's intended purpose admirably. The text is presented as a guide to "everything which a practicing physician or a gynecologist should know concerning the practice of gynecology in an office or outpatient surgery room." The author lists the indications and contraindications as well as the rationale and technique for all office gynecologic procedures, with emphasis on the early detection of cancer. In addition, the author's emphasis on the limitations of clinical endocrinology, his appreciation of and clear discourse on psychosomatic and psychosexual problems, and his coverage of common gynecologic entities clearly warrant the inclusion of this book in a list of *The General Practice Manuals.*

—Frank M. Maher.

A 522 PAGE COMPILATION of articles by 60 different authors, *Gynecology; Surgical Techniques,*[11] has been edited by Robert Lowrie. The geographic distribution of these authors makes it obvious to this middle western reviewer that ability in gynecologic surgery is pretty well confined to the Atlantic seaboard.

Seventy-eight chapters have been written by the 60 authors. Practically every chapter is concerned with operative procedures, major or minor, running the gamut of "Subcutaneous Implantation of Pellets in Hormone Therapy" to "Complete Excision of Pelvic Viscera for Advanced Carcinoma." The book includes 9 articles on operations on the vulva and its component structures, 4 of which have to do with Bartholin's gland. There are 13 articles on operations on the vagina, not including 10 chapters on the treatment for urinary fistulas and for correction of stress incontinence, nor 8 others on procedures designed to correct "vaginal" prolapse. These chapters make up the first half of the book. It is obvious from these samples that the coverage is most complete and, in a few instances, repetitious.

Illustrations are profuse. In one chapter alone there are 55 illustrations. They are numbered separately for each chapter and therefore the reviewer had no idea

[9] CIRUGÍA DE LAS INFECCIONES MAXILARES Y PERIMAXILARES; CLINICA Y TRATAMIENTO. By José Yoel and Eldo A. Bilesio. 204 pages, 134 illustrations. Editorial Bibliografica Argentina, 1955.

[10] OFFICE GYNECOLOGY. By J. P. Greenhill, B.S., M.D., F.A.C.S., F.I.C.S. 6th rev. enl. ed. 517 pages, 127 illustrations. $7.75. Chicago: The Year Book Publishers, Inc., 1954.

[11] GYNECOLOGY; SURGICAL TECHNIQUES. Compiled and edited by Robert J. Lowrie, M.A., M.D., F.A.C.S. Foreword by J. P. Greenhill, M.D. 523 pages, illustrated. $17.75. Springfield, Illinois: Charles C Thomas, 1955.

as to the total number. Most of the illustrations are of good quality.

According to the preface, the book should be of value to the general practitioner, the obstetrician, "even if he devotes little time to gynecology," the general surgeon, the aspirant to gain specialty certification, and to the medical student. The reviewer agrees that it would be of value to those in the first four categories but not in the last. The medical school curriculum is already too full. The learning of special operative techniques should be in preparation for and part of the residency training. —*Ronald R. Greene.*

THE FIRST EDITION OF *Obstetrical Anesthesia; Its Principles and Practice*[12] is a general survey of the problems, both anesthetic and medical, encountered in the obstetric patient. Particular emphasis is placed on the "fundamental facts underlying careful clinical observation during the conduct of anesthesia for the purpose of safer obstetrical anesthesia."

Following a summary of the history of obstetric anesthesia and analgesia, the author devotes a chapter to a discussion of the concept of reflex irritability. Because of the marked differences in this level between the mother and the fetus, the choice of any premedicating or anesthetic agent which alters this level is of great importance. Factors which tend to elevate or depress irritability are mentioned.

The sections which are concerned with the pain of labor and premedication for the obstetric patient are especially informative. After a summary of the theories explaining the labor pain, a detailed description of the associated motor and sensory nerve supply is presented with several good diagrams. Of particular interest is a detailed description of the plan for premedicating the obstetric patient at Boston Lying-In Hospital where apormorphine and scopolamine are in routine use.

Included in the book is a good survey of the problems and complications associated with asphyxia neonatorum. Fetal respiratory activity and the effects of anoxia upon the respiratory movements are discussed. There is a classification of asphyxia neonatorum, a discussion of its causes, the pathologic findings in such cases, and a plan for its management or prevention.

Of particular value are the chapters in which the selection of anesthetic agents and techniques is discussed, both inhalation and regional. The diagrams and illustrations which accompany the section on regional block are very good. The methods and techniques, indication for and against spinal block, epidural block, pudendal nerve block, and local analgesia are listed.

The final chapter deals with complications of pregnancy such as anemia and hemorrhage. There are lengthy discussions of myasthenia gravis, heart disease, poliomyelitis in pregnancy, aspiration, pneumonitis, and diabetes.

"*Obstetrical Anesthesia* has been designed for the student of medicine, the practicing physician, and the obstetrician in order to clarify the purposes of the anesthesiologist. This book discusses clearly the fundamental principles of obstetrical anesthesia and should be of value to the beginner, the medical student, the general practitioner, the obstetrician-in-training, the occasional anesthetist, and others who are called upon to administer anesthetic to the obstetrical patient." —*Mary Karp.*

KANAVEL'S TEXTBOOK on *Hand Infections* has often been referred to as the Bible in surgery of the hand. The excellent volume entitled *Surgery in World War II; Hand Surgery*[13] edited by Sterling Bunnell could well be called the Acts of the Apostles. This volume of 447 pages with 224 illustrations incorporates the summaries and reports of 12 doctors from the various theaters of operations overseas and the 9 hand centers in the Zone of Interior during World War II. The report in each chapter is in itself an excellent summary of the fundamental principles in surgery of the hand. In the report from the Zone of the Interior, the outline in each chapter in general is as follows:

Initially, problems dealing with administration are discussed. The organization of a special hand center is emphasized, and the union of general surgeon, neurosurgeon, orthopedic surgeon, and plastic surgeon all working together to give birth to hand surgeons is also emphasized. Subjects discussed are adequate initial care, skin graft procedures, both primary and late, and the treatment of fractures with malunion and nonunion. Capsulectomy and capsulotomy of joints are mentioned. Nerve repair with and without the utilization of nerve grafts is reported. Primary and secondary tendon repairs are discussed. Tendon grafting procedures are presented. The treatment of burns and of severe contractures following burns is excellently illustrated. Discussions of the problems following amputation, along with the decision as to whether or not the digit should be amputated, are presented. Tendon transplants with excellent discussion and illustration in several chapters are presented in detail.

An excellent section by the late Harvey S. Allen covering 74 pages is presented. Here the principles of early care of the injured hand are emphasized. The basic concepts of a compression type of dressing, adequate reduction of fractures, treatment of nerve and tendon injuries, and care of amputations and burns are well emphasized. In addition, in this chapter a section is set aside for the treatment of causalgia and psychogenic factors, such as hysteria, anxiety states, and malingering.

Since it was thought it would be better for each doctor to tell the story of his own area, a good deal of repetition is necessary, as Bunnell points out. Certain conflicts are encountered from these individual reports, as one would expect. For example, in the Mediterranean Theater primary tenorrhaphies were attempted and motion was started within 2 or 3 days with, according to the author, poor results. However, in a General Hospital in England early motion was started with good results. In some sections of the book pulp traction was recommended for fractured fingers, whereas in other sections of the book, it was deplored.

[12]OBSTETRICAL ANESTHESIA; ITS PRINCIPLES AND PRACTICE. By Bert B. Hershenson, M.D. With a foreword by Frederick C. Irving, M.D. 403 pages, 50 illustrations. $9.50. Springfield: Charles C Thomas, 1955.

[13]SURGERY IN WORLD WAR II; HAND SURGERY. Edited by Sterling Bunnell, M.D. 447 pages, 224 illustrations. $3.75. Washington, D. C.: War Department, Office of Surgeon General, Department of the Army, 1955.

There was a good deal of controversy about the use of the whirlpool bath in postoperative care. However, these differences are all carefully blended and the best methods of treatment are presented in an excellent summary by Doctor Bunnell.

The author states that of the 592,170 wounded about 25 per cent, or 148,024 injuries, are of the upper extremity and of these 50 per cent or 88,825, affected the hand. The editor gives the Surgeon General, Major General Norman T. Kirk, credit for much of the success achieved in World War II in salvaging crippled hands. He states that it was due to his vision and initiative that these various hand centers were started. However, throughout each report the influence, guidance, and instructions of Doctor Bunnell can be seen. He worked untiringly and unceasingly giving many courses of instructions in surgery of the hand. He has provided an excellent summary of the initial and late treatment of injured hands with a description of the pitfalls encountered and the corrective measures to overcome these. The book in itself is excellent reading, and it would be very informative for anyone interested in both the early and late care of the injured hand. It is truly a monument to Bunnell and the other surgeons who worked so hard to save the many injured hands encountered in World War II.—*Joseph L. Posch.*

BOOK REVIEWS

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Hospital Patient Survey; an Evaluation of the Basic Characteristics, Medical Findings, and Potential Disposition of the Patients in the New York Municipal Hospital System with Special Reference to the Problems of Chronic Disease and Custodial Care. By Howard A. Rusk, M.D., Dir., John E. Silson, M.D., M.P.H., Joseph Novey, M.S.W., and Michael M. Dacso. 146 pages, 77 tables. Supported by the New York Foundation, 1956.

Le complicazioni dell'aortografia toracica e addominale e loro trattamento. By Manfredi Servello and Leonardo Lojacono. 64 pages, 16 illustrations. Padova: Cedam, 1956.

Chirurgische Indikationen. By Rudolf Nissen. 299 pages, 15 illustrations, and 9 tables. DM42. Stuttgart: Georg Thieme Verlag, 1956.

How to Enjoy Good Health. Edited by Cyril Solomon, M.D., and Brooks Roberts. 240 pages, not illustrated. $3.95. New York: Random House, 1956.

Medizinische Röntgentechnik; Lehrbuch fuer medizinisch-technische Assistentinnen, Aerzte und Studierende. I, Medizinischer Teil; Skelettaufnahmen und Organuntersuchungen. By Prof. Dr. Herbert Schoen. 347 pages, 534 illustrations. DM29.70. Stuttgart: Georg Thieme Verlag, 1956.

The Happy Life of a Doctor. By Roger I. Lee, M.D. 278 pages, illustrated. $4.00. Boston: Little, Brown & Co., 1956.

Operative Surgery. Abdomen (complete). Edited by Charles Rob, M.C., F.R.C.S., and Rodney Smith, M.S., F.R.C.S. Vol. II. 407 pages, illustrated. London: Butterworth & Co., Ltd., 1956.

World Trends in Cardiology: I, Cardiovascular Epidemiology. Edited by Ancel Keys, Ph.D., and Paul D. White, M.D. 193 pages, 41 illustrations. New York: Paul B. Hoeber, Inc., 1956.

World Trends in Cardiology: II, Cardiovascular Surgery. Edited by Helen B. Taussig, M.D., and Arthur S. Cain, Jr., M.D. 65 pages, not illustrated. New York: Paul B. Hoeber, Inc., 1956.

World Trends in Cardiology: III, Blood Volume and Contractile Protein in Heart Muscle. Edited by Arthur S. Cain, Jr., M.D. 131 pages 41 illustrations. New York: Paul B. Hoeber, Inc., 1956.

World Trends in Cardiology: IV, Cardiovascular Diagnosis and Therapy. Edited by Arthur S. Cain, Jr., M.D. 95 pages, 8 illustrations. New York: Paul B. Hoeber, Inc., 1956.

World Trends in Cardiology: V, Instrumental Methods in Cardiac Diagnosis. Edited by Louis N. Katz, M.D., and Arthur S. Cain, Jr., M.D. 100 pages, 11 illustrations. New York: Paul B. Hoeber, Inc., 1956.

Anatomy of the Trigonum Vesicae and the Aetiology and Treatment of Spontaneous and Traumatic Obstetrical Urogenital Fistulae. With summaries in Dutch, English and French. By D. A. E. Norel, M.D., M.D.Sc. 239 pages, 19 illustrations. The Netherlands: Dekker & Van De Vegt, 1956.

Technique chirurgicale en figures. By Prof. G. Jeanneney and Prof. J. Magendie. 488 pages, 1,625 illustrations. 8.200 fr. Paris: G. Doin & Co., 1956.

Atlas of Tumors of the Nervous System. By H. M. Zimmerman, M.D., Martin G. Netsky, M.D., and Leo M. Davidoff, M.D. 191 pages, 277 illustrations, 233 in color. $25.00. Philadelphia: Lea & Febiger, 1956.

Clinical Orthopaedics. By Anthony F. DePalma. With the assistance of the Associate Editors, the Board of Advisory Editors, and the Board of Corresponding Editors. No. 8. 337 pages, illustrated. $7.50. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

Carcinoma of the Breast; the Study and Treatment of the Patient. By Andrew G. Jessiman, F.R.C.S., M.D., and Francis D. Moore, M.D. 135 pages, 21 illustrations. $4.00 Boston and Toronto: Little, Brown & Co., 1956.

History of the American Board of Surgery 1937-1952. By J. Stewart Rodman, M.D. 104 pages, illustrated. $3.00. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

Equilibrio endocrino in gravidanza la triade preipofisi-placenta-ovaio. By F. Vozza, G. Nicora, and F. E. Mansani. VI Congresso Nazionale. 295 pages, 46 illustrations. Parma: Scuola Tipografica Benedettina, 1956.

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Contains potassium chloride, potassium glutamate, glutamic acid, calcium silicate, potassium iodide (0.01%).

2 oz. shakers and 8 oz. bottles

Sold Only Through Drugstores.

Winthrop LABORATORIES
NEW YORK 18, N. Y.

TASTES
LOOKS
POURS
USED
} LIKE SALT

Assures patient cooperation

Neocurtasal, trademark reg. U.S. Pat. Off.

". . . best results were obtained with women 35 to 55 years of age, who complained of anxiety, insomnia, chronic fatigue and despondency."[1]

Many physicians have reported favorable results with 'Compazine' in the mild or moderate mental and emotional conditions often associated with the menopause.

For example, in a series of 84 patients, Knoch and Kirk report outstanding results in women 35 to 55. The authors state that after 'Compazine' treatment, these women "were no longer fatigued, were sleeping well, had increased energy and showed a lively interest in their surroundings."

'Compazine' is S.K.F.'s new tranquilizer and antiemetic for everyday practice.

'Compazine' has shown minimal side effects.

Compazine*

a true tranquilizing agent

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1. Knoch, H.R., and Kirk, R.: Proclorperazine—A New Agent for the Treatment of Psychic Stress, in manuscript.

*Trademark for proclorperazine, S.K.F.

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